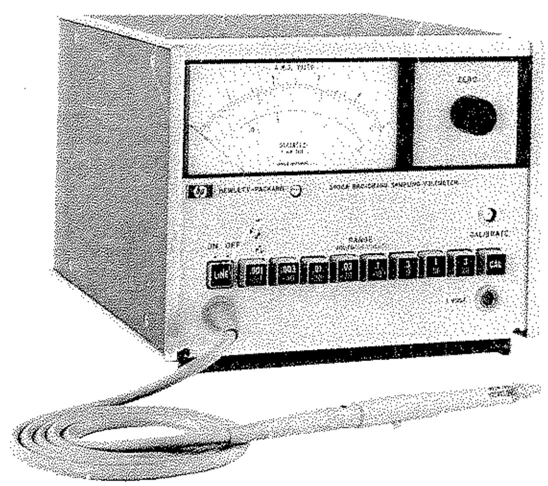
-hp- 3406A

OPERATING AND SERVICE MANUAL

BROADBAND SAMPLING VOLTMETER

3406A



HEWLETT PACKARD

-hp- 3406A

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OPERATING AND SERVICE MANUAL

MODEL 3406A BROADBAND SAMPLING VOLTMETER

SERIAL NUMBER: 1722A04641

IMPORTANT NOTICE

If the Serial Number of your instrument is lower than the one on this title page, the manual contains revisions that do not apply to your instrument. Backdating information given in the manual adapts it to earlier instruments.

Where practical, backdating information is integrated into the text, parts list and schematic diagrams. Backdating changes are denoted by a delta sign. An open delta (Δ) or lettered delta (Δ_A) on a given page, refers to the corresponding backdating note on that page. Backdating changes not integrated into the manual are denoted by a numbered delta (Δ_1) which refers to the corresponding change in the Backdating section (Section VIII).

WARNING

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

Manual Part No. 03406-90005

Microfiche Part No. 03406-90055

P.O. box 301, Loveland, Colorado 80537 U.S.A.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF TABLES

LIST OF ILLUSTRATIONS

HEWLETT PACKARD

SAFETY SUMMARY

The following general safety 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 this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

To minimize shock hazard, the instrument chassis and cabinet must be connected to an electrical ground. The instrument is equipped with a three-conductor ac power cable. The power cable must either be plugged into an approved three-contact electrical outlet or used with a three-contact to two-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet International Electrotechnical Commission (IEC) safety standards.

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

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.

KEEP AWAY FROM LIVE CIRCUITS

Operating personnel must not remove instrument covers. Component replacement and internal adjustments must be made by qualified maintenance personnel. Do not replace components with power cable connected. Under certain conditions, dangerous voltages may exist even with the power cable removed. To avoid injuries, always disconnect power and discharge circuits before touching them.

DO NOT SERVICE OR ADJUST ALONE

Do not attempt internal service or adjustment unless another person, capable of rendering first aid and resuscitation, is present.

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

Because of the danger of introducing additional hazards, do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to a Hewlett-Packard Sales and Service Office for service and repair to ensure that safety features are maintained.

DANGEROUS PROCEDURE WARNINGS

Warnings, such as the example below, precede potentially dangerous procedures throughout this manual. Instructions contained in the warnings must be followed.

WARNING

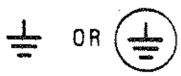
Dangerous voltages, capable of causing death, are present in this instrument. Use extreme caution when handling, testing, and adjusting.

SAFETY SYMBOLS

General Definitions of Safety Symbols Used On Equipment or In Manuals.

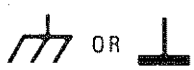
Instruction manual symbol: the product will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect against damage to the instrument.

Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



Protective conductor terminal. For protection against electrical shock in case of a fault. Used with field wiring terminals to indicate the terminal which must be connected to ground before operating equipment.

Low-noise or noiseless, clean ground (earth) terminal. Used for a signal common, as well as providing protection against electrical shock in case of a fault. A terminal marked with this symbol must be connected to ground in the manner described in the installation (operating) manual, and before operating the equipment.



Frame or chassis terminal. A connection to the frame (chassis) of the equipment which normally includes all exposed metal structures.

Alternating current (power line).

Direct current (power line).

Alternating or direct current (power line).

WARNING

The WARNING sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death to personnel.

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition 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.

NOTE:

The NOTE sign denotes important information. It calls attention to procedure, practice, condition or the like, which is essential to highlight.

Table 1-1. Specifications

Voltage Range:
1 mV to 3 volts full scale in eight ranges; decibels from - 50 to + 20 dBm (0 dBm = 1 mW into 50 ohms); absolute average-reading instrument calibrated to rms value of sine wave.

Frequency Range:
10 kHz to 1.2 GHz; useful sensitivity from 1 kHz to beyond 2 GHz.

Full-Scale Accuracy (%) with Appropriate Accessory:
(after probe is properly calibrated)

10 kHz	20 kHz	25 kHz	100 kHz	100 MHz	700 MHz	1 GHz	1.2 GHz
±13	±8	±5	±3	±5	±8	±13	

Input Impedance:
Input capacity and resistance will depend upon accessory tip used. 100,000 ohms shunted by less than 2.1 pF at 100 kHz with bare probe; less than 10 pF with 11072A isolator tip supplied.

Sample Hold Output:
Provides ac signal whose unclamped portion has statistics that are narrowly distributed about the statistics of the input, inverted in sign, (operating into greater than 200 kilohm load with less than 1000 pF).

Sample Hold Noise:
less than 175 uV rms.

Accuracy (after probe is properly calibrated):
0.01 V Range and Above: Same as Full Scale Accuracy of instrument.
0.001 V to 0.003 V Range: Value of input signal, can be computed by taking into account the residual noise of the instrument.

Jitter:
Meter indicates within ± 2% peak of reading, 95% of the time (as measured with an HP Model 3400A true rms voltmeter).

RMS Crest Factor: 0.001 V to 0.3 V: 20 dB.
1 V: 13 dB.
3 V: 3 dB.

Meter

Meter Scales:
Linear voltage, 0 to 1 and 0 to 3; decibel, - 12 to + 3. Individually calibrated taut band meter.

Response Time:
Indicates within specified accuracy in less than 3 sec.

Jitter:
± 1% peak (of reading).

General

DC Recorder Output:
Adjustable from zero to 1.2 mA into 1000 ohms at full scale, proportional to meter deflection.

Overload Recovery Time:
Meter indicates within specified accuracy in less than 5 sec (30 V p-p max).

Maximum Input:
± 100 V dc, 30 V p-p.

RFI:
Conducted and radiated leakage limits are below those specified in MIL-6181D and MIL-1-16910C except for pulses emitted from probe. Spectral intensity of the pulses are nominally 50 $nV/\sqrt{Hz}$; spectrum extends beyond 2 GHz.

Temperature Range:
Instrument: 0 to + 55° C.
Probe: + 10° C to + 40° C.

Power:
115 ± 10%, 48 Hz to 440 Hz, 230 V ± 10% 48 - 66 Hz
25 VA Max.

Dimensions:
Standard 1/2 module 6-1/2 in high, 8-7/8 in. wide, 11-1/2 in. deep (165x225x292 mm).

Weight:
Net 12 lbs. (5,4 kg).

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. This section contains general information about the Model 3406A Broadband Sampling Voltmeter. A general description and various applications of the instrument are described in the following paragraphs. The published specifications are given in Table 1-1. The accessories supplied with the instrument and accessories available are identified in Table 1-2 and 1-3. Instrument/Manual Identification is also included in this section.

1-3. DESCRIPTION.

1-4. The Model 3406A Broadband Sampling Voltmeter is an easy-to-use high-frequency voltmeter incorporating an incoherent sampling technique for accurate measurements over a wide frequency range. Using the sampling technique, the accuracy of the Model 3406A is ± 3% of full scale at frequencies between 100 kHz and 100 MHz. Eight voltage ranges, selected by front panel pushbuttons, enable the 3406A to measure voltages from 1 mV to 3 volts full scale with 20 uV resolution on the 1 mV range.

1-5. The meter features two easy-to-read linear voltage scales (0 to 1 and 0 to 3) calibrated in the rms value of a sine wave, and a dBm scale of - 12 to + 3 referenced to 50 ohms. (Zero dBm is equal to one milliwatt dissipated across 50 ohms). Each range is calibrated in 10 dBm steps for power or gain measurement from - 62 to + 23 dBm in a 50 ohm system. The meter movement is individually calibrated and average-responding on all ranges. An overload circuit within the voltmeter protects the meter movement and internal circuits during specified overload on any range. Recovery time after an overload is less than 5 seconds.

1-6. The input impedance of the Model 3406A depends upon the accessory probe tip used, and the frequency of the signal being measured. Typically, the input impedance is 100 kilohms at 100 kHz in parallel with 2 pF. Using the 11072A Isolator Tip to eliminate the effect of source resistance, the total input shunt capacitance is between 9 and 10 pF. Input impedance curves as well as frequency range and use of various probe tips are given in Section III of this manual.

1-7. The 3406A is equipped with a slenderized probe for ease of measurement. A pushbutton located on the probe case retains the meter deflection when depressed. This makes possible measurements in awkward positions where it is difficult for the operator to place the probe in the circuit under test and at the same time read the meter.

1-8. FRONT PANEL CALIBRATION.

1-9. The Model 3406A provides a means of "calibrating" and "zeroing" the voltmeter from the front panel with no external test equipment. With the probe inserted into the 1 VOLT receptacle on the front panel and the CAL pushbutton released (out) the instrument may be zeroed in the presence of an RF field. When the CAL pushbutton is depressed an internal calibrator voltage is provided at the 1 VOLT receptacle. This voltage is used as a reference to adjust the gain of the Signal Amplifier within the 3406A for a 1 volt deflection on the meter. Since the sampling efficiency of 3406A depends upon the probe tip used, the Signal Amplifier gain is adjusted, via the front panel CALIBRATE control, each time the probe tip is changed. Refer to Section III for front panel zero and calibrate procedures. Refer to Section IV for definition of sampling efficiency.

1-10. APPLICATION.

1-11. In addition to voltage or dBm measurements on the 3406A meter, two outputs are provided on the rear panel to extend the measuring capabilities and usefulness of the Model 3406A.

1-12. RECORDER OUTPUT.

1-13. The RECORDER OUTPUT on the rear panel provides a dc output proportional to meter deflection. The dc RECORDER OUTPUT is used to drive auxiliary equipment, record measurements on a dc recorder, or digital voltmeter or it may be used as a high frequency AC-to-DC converter. The RECORDER OUTPUT may also be used to control the output level of a broadband signal generator which has dc modulation capability by monitoring the generator output with the the 3406A.

1-14. SAMPLE HOLD OUTPUT.

1-15. A SAMPLE HOLD OUTPUT is also provided at the rear of the instrument. A signal statistically equivalent to the input signal being measured is made available at this output. The frequency of the SAMPLE HOLD OUTPUT is within the audio spectrum, even for input signals up to 2 GHz. Examples of statistically equivalent signals are given in Figure 3-2.

1-16. True rms and peak voltage values, amplitude modulation envelopes, pulse height information, and probability density functions of broadband signals can be determined by observing the SAMPLE HOLD OUTPUT. Refer to Section III for additional information on sample hold output measurements and how to take them.

1-17. INSTRUMENT AND MANUAL IDENTIFICATION.

1-18. The instrument serial number is located on the rear panel. Hewlett-Packard uses a two-section serial number consisting of a four-digit prefix and a five-digit suffix. A letter between the suffix and prefix identifies the country in which the instrument was manufactured (A = USA, G = West Germany, J = Japan, U = United Kingdom). All correspondence with Hewlett-Packard should include the complete serial number.

1-19. If the serial number of your instrument is lower than the one on the title page of this manual, refer to Section VIII for backdating information that will adapt this manual to your instrument.

1-20. ACCESSORIES/EQUIPMENT SUPPLIED.

1-21. The accessories and equipment supplied with each Model 3406A are listed in Table 1-2. An additional operating and service manual may be ordered as Option 910, Part Number 03406-90004.

1-22. ACCESSORIES AVAILABLE.

1-23. Accessories available to increase the test capabilities of the Broadband Sampling Voltmeter are described briefly in Table 1-3. The Model 3406A accessories are available in two accessory probe kits shown in Figures 1-1 and 1-2, however, each accessory may be purchased individually if desired. Contact your local -hp- Sales and Service Office for additional information (see Appendix B for office locations). To select the proper probe tip or adapter for various measurements, refer to the typical impedance curves and frequency range data given in Section III.

Table 1-2. Accessories/Equipment Supplied

DESCRIPTION	-HP- PART NO.	QUANTITY
Isolator Probe Tip	11072A	1
Nut Driver	8710-0084	1
Replacement Tips	5020-0457	10
Ground Clips	10213-62102	2
Ground Lead	5060-4991	1
Power Cord	8120-1348	1
Operating and Service Manual	03406-90004	1
Operating Note (Red)	7124-0339	1

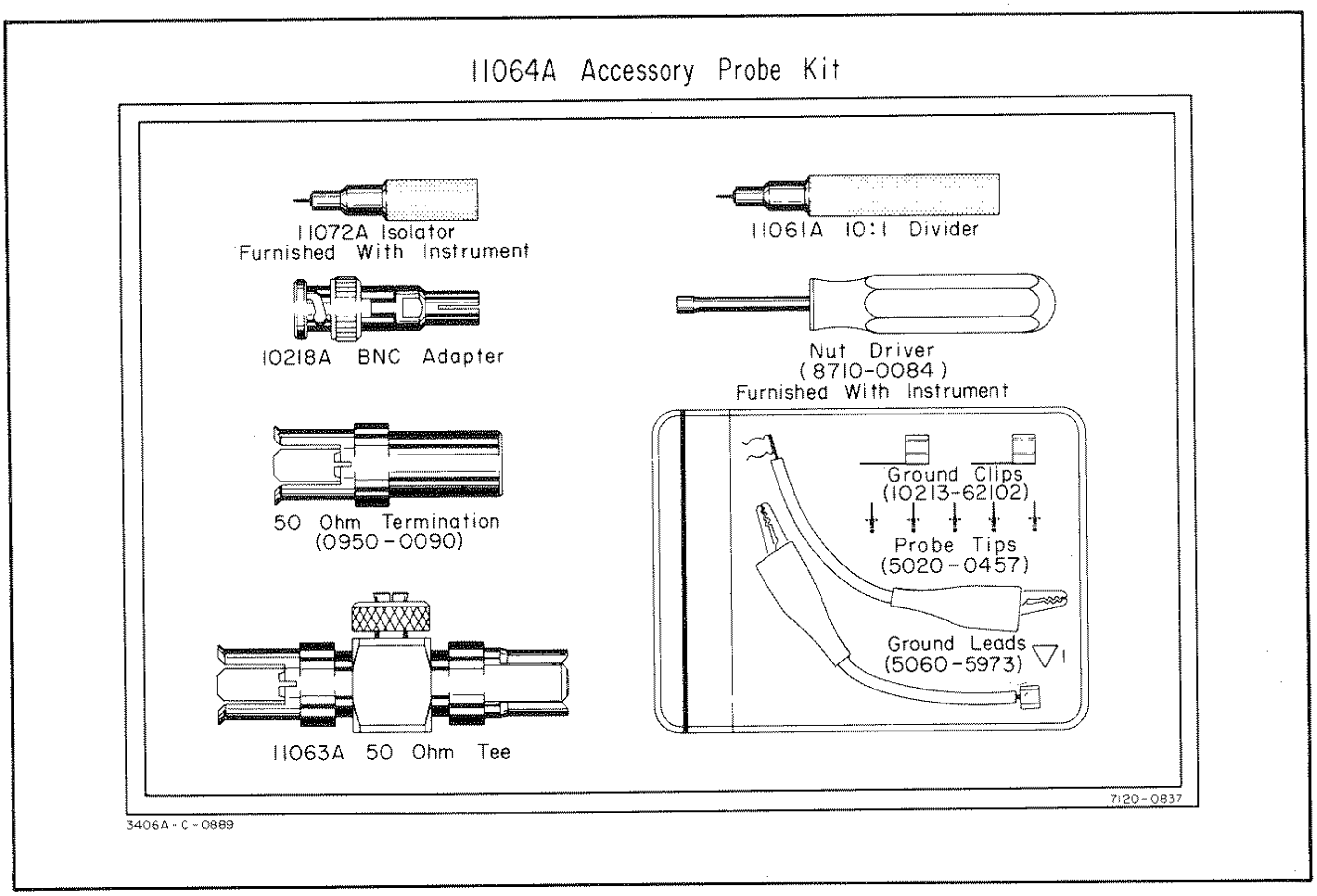


Figure 1-1. 11064A Basic Probe Kit.

Table 1-3. Accessories Available

MODEL	TITLE	PURPOSE
11061A	10:1 Divider	Decreases input sensitivity of Model 3406A by a factor of ten (maximum sensitivity with divider is 30 V full scale).
10218A	BNC Adapter	* Permits connection of Isolator or 10:1 Divider to female BNC connector. DO NOT USE WITH BARE PROBE IF ABSOLUTE READINGS ARE DESIRED.
11063A	50 Ohm Tee	Permits monitoring of signal in 50 ohm system without disturbing the line or attenuating the signal on the line.
—	50 Ohm Termination	Terminates signals in a 50 ohm system (use with 50 Ohm Tee).
11073A	Pen-Type Isolator Note If 11073A is ordered individually only the alligator clip and a ground lead will be supplied with the order.	Permits the probe to be clipped on or connected to the point of measurement using one of the following accessories: 1. Alligator clip (5060-0416) 2. Pincer Jaw (5060-5979) 3. Pin Tip (5060-0418) 4. Hook Tip (5060-0419) 5. Spring Tip (5060-0420) 6. Banana Tip (1251-0013)
10219	Type 874A Adapter	* Permits connection of Isolator or 10:1 Divider [illegible]eral Radio Co. Type 874 coaxial connector. DO NOT USE WITH BARE PROBE IF ABSOLUTE READINGS ARE DESIRED.
10220A	Microdot Adapter	* Permits connection of Isolator or 10:1 Divider to Microdot connector. DO NOT USE WITH BARE PROBE IF ABSOLUTE READINGS ARE DESIRED.
11064A	Basic Probe Kit (See Figure 1-1)	Includes: 11063A 50 Ohm Tee 50 Ohm Termination 11061A 10:1 Divider 10218A BNC Adapter Bag of probe tips and ground leads
11071A	Complete Probe Kit (See Figure 1-2)	Includes: 11063A 50 Ohm Tee 50 Ohm Termination 11061A 10:1 Divider 10218A BNC Adapter 10219A Type 874A Adapter 10220A Microdot Adapter 11073A Pen type Isolator with alligator clip, pincer jaw, and all accessory tips. Bag of probe tips and ground leads

* See Paragraph 3-11 in Section III.

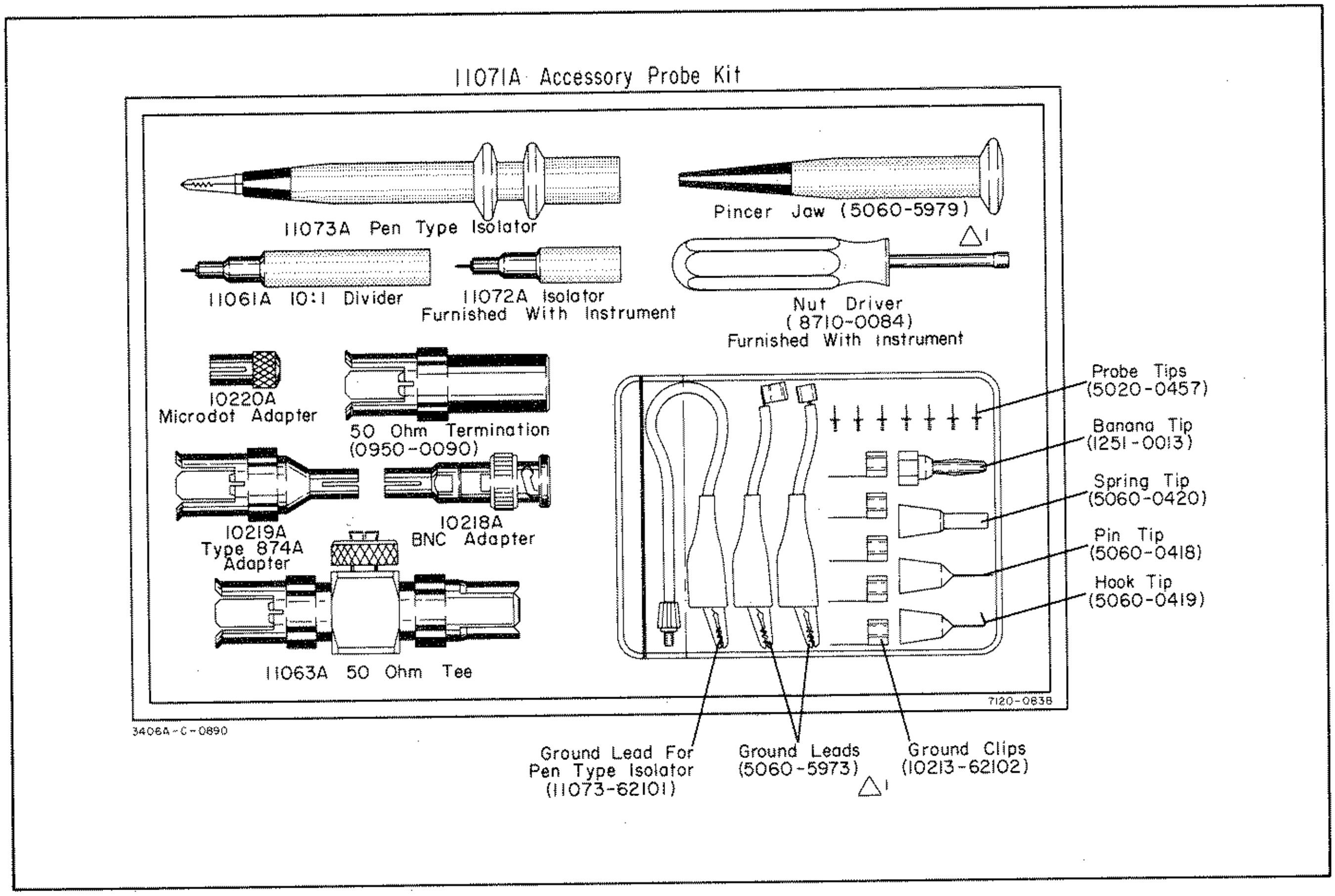


Figure 1-2. 11071A Complete Probe Kit.

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section includes information and instructions necessary for the installation or shipment of this instrument. Included is information pertaining to initial inspection, installation, and repackaging for shipment.

2-3. INSPECTION.

2-4. This instrument was carefully inspected both mechanically and electrically before shipment. It should be physically free of mars or scratches and in perfect electrical order upon receipt. To confirm this, the instrument should be inspected for physical damage. Also, the electrical performance of the instrument should be tested using the procedure outlined in Section V of this manual. If there is damage or deficiency, see the warranty at the front of this manual.

2-5. POWER REQUIREMENTS.

2-6. This instrument will operate from either 115 or 230 V ac, 48 Hz to 66 Hz. The instrument can easily be converted from 115 volt to 230 volt operation by changing the position of the slide switch located on the rear panel so that the designation appearing on the switch matches the nominal voltage of the power source.

2-7. Figure 2-1 illustrates the standard power plug configurations that are used throughout the United States and in other countries. The -hp- part number shown directly above each plug drawing is the part number for a 3406A power cord equipped with the proper plug. If the appropriate power cord is not included with the instrument, notify the nearest Hewlett-Packard office and a replacement cord will be provided.

2-8. GROUNDING REQUIREMENTS.

2-9. For the safety of operating personnel, the instrument must be grounded. The offset pin on the power cable grounds the instrument when plugged into the proper receptacle.

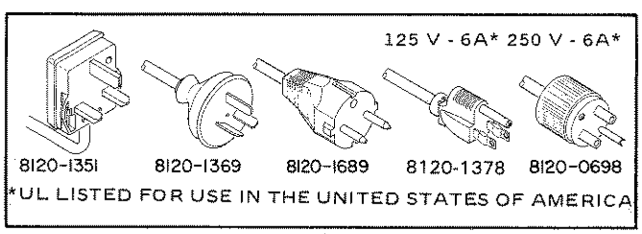


Figure 2-1. Power Plugs.

2-10. RACK/BENCH INSTALLATION.

2-11. This instrument is initially shipped as a bench-type instrument with plastic feet and tilt stand in place. This instrument can be rack mounted by using a rack mounting kit available at your nearest -hp- Sales and Service Office.

2-12. REPACKAGING FOR SHIPMENT.

2-13. The following is a general guide for repackaging for shipment. If you have any question, contact your local -hp- Sales and Service Office. (See Appendix at the back of this manual for office location.)

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, serial number and serial number prefix.

2-14. Place the instrument in its original container if available. If the original container is not available, a suitable one can be purchased from your nearest -hp- Sales and Service Office.

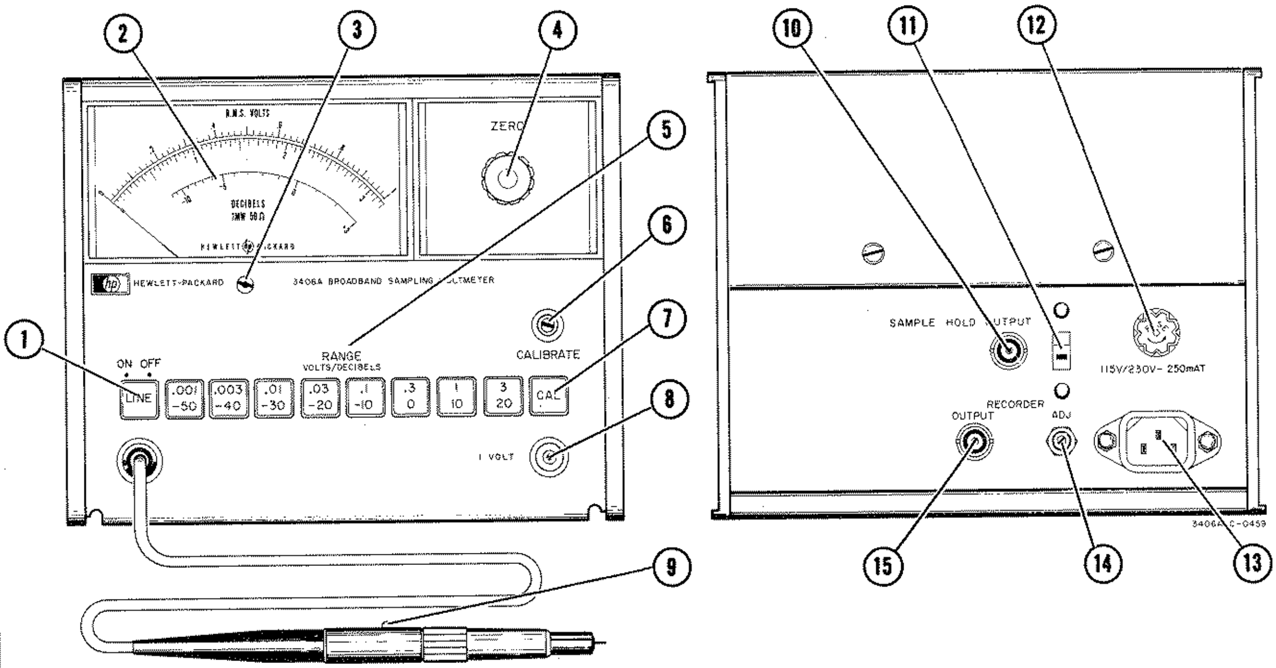
2-15. If the original container is not used:

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

b. Use plenty of packing material around all sides of the instrument and protect panel faces with cardboard strips.

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

d. Mark the shipping container with "DELICATE INSTRUMENT," "FRAGILE" etc.



(1) LINE OFF Pushbutton: disconnects ac operating power applied to instrument when depressed.

(2) Meter: indicates level of applied input signal in volts or dBm.

(3) Mechanical Zero Adjustment: screwdriver adjustment for mechanically zeroing of meter movement. (See Paragraph 5-19.)

(4) ZERO Control: provides variable control of zero offset on all ranges.

(5) RANGE Pushbuttons: applies ac operating power to instrument, and selects input voltage range.

(6) CALIBRATE Control: a screwdriver adjustment for calibrating the instrument per probe tip in use. (See note under Paragraph 3-9.)

(7) CAL Pushbutton: connects internal calibrator voltage to the 1 VOLT receptacle when depressed.

(8) 1 VOLT Receptacle: provides connections for probe, with or without probe tip, when zeroing or calibrating the instrument. (See Paragraphs 3-8 and 3-9.)

(9) Meter Hold Pushbutton: retains the meter indication when depressed.

(10) SAMPLE HOLD OUTPUT: provides connection for measuring peak and true rms value of input signal above 0.5 mV (See Paragraph 3-33 for application).

(11) Line Voltage Slide Switch: selects 115 or 230 Vac source for the operating power of the instrument. Voltage selected appears on switch.

(12) FUSE: protects internal circuits of instrument (1/4 amp slow-blow for both 115 and 230 Vac operation).

(13) Power Input Connector: connects ac operating power to instrument through power cord furnished with instrument.

(14) RECORDER ADJ: screwdriver adjustment for varying the RECORDER OUTPUT between zero and 1.2 Ma into 1000 ohms at full scale.

(15) RECORDER OUTPUT: provides a dc output proportional to meter deflection with full scale value determined by the RECORDER ADJ

Figure 3-1. Front and Rear Panel Controls, Indicators and Connectors

SECTION III
OPERATING INSTRUCTIONS

3-1. INTRODUCTION.

3-2. This section contains instructions and information necessary for operation of the Model 3406A Broadband Sampling Voltmeter. Included are turn-on procedures, operating instructions, probe tip selection, and SAMPLE HOLD OUTPUT applications. Also included in this section are front panel ZERO and CALIBRATE procedures.

3-3. FRONT AND REAR PANEL CONTROLS, INDICATORS, AND CONNECTORS.

3-4. The function of the front and rear panel controls, indicators, and connectors is identified in Figure 3-1.

3-5. TURN-ON PROCEDURE.

3-6. To turn-on, zero and calibrate the Model 3406A, proceed as follows:

3-7. TURN-ON.

a. Position the Line Voltage Switch (12, Figure 3-1) on the rear panel to the source voltage to be used. Connect the power cord.

b. Depress the 1 volt RANGE Pushbutton (6) and verify that LINE indicator (2) lights.

3-8. ZERO.

a. With the CAL Pushbutton (8) released (out) insert probe with Isolator Tip (11072A) into the 1 VOLT receptacle (9).

b. Adjust ZERO control (5) for zero indication on Meter (3).

c. The zero adjustment for the upper five ranges (.03 to 3 volt range) may be performed on any one of the upper five ranges. On the .01, .003 and .001 volt ranges zero the voltmeter on the range selected prior to taking any measurements on that range.

d. If the probe body temperature exceeds 30° C when using the .001 V range, special zeroing procedures are necessary. For readings below 1/3 scale zero the 3406A on the 1 mV range with the probe inserted into a terminated 50 ohm tee at the temperature of measurement. For readings above 1/3 scale zero the 3406A on the 1 V range with the probe inserted into a terminated 50 ohm tee at the temperature of the measurement. If a 50 ohm tee is not available, insert the probe at temperature of the measurement into the 1 V receptacle with the CAL pushbutton released and adjust ZERO as rapidly as possible.

3-9. CALIBRATE.

a. With probe in 1 VOLT receptacle, (with Isolator Tip attached) depress CAL.

b. Adjust the CALIBRATE control (7) with a screwdriver for 1 volt indication on meter.

c. Remove probe from 1 VOLT Receptacle, and release CAL Pushbutton.

NOTE

Since the sampling efficiency of the 3406A voltmeter depends on the probe tip (accessory) used, the front panel "CALIBRATE" procedure is used to compensate the meter indication for the probe tip in use. Zero and calibrate the voltmeter each time the probe tip is changed or when just the bare probe is used with or without the 50 ohm tee. Refer to Paragraph 3-27 for information on how to zero and calibrate the voltmeter per probe tip or adapter selected. Refer to Section IV for definition of sampling efficiency.

3-10. OPERATING INSTRUCTIONS.

3-11. The 3406A is designed to be used with either the Isolator Tip or one of the accessories available in the Base Probe Kit (11064A) or the Complete Accessory Kit (11071A). NO OTHER PROBE TIP OR CONNECTOR IS APPLICABLE. For proper selection of probe tip, refer to Table 1-3 and the frequency response and input impedance curves given in this section. All measurements require proper grounding of probe. Use one of the ground clips supplied with the 3406A or one of the ground leads in the Accessory Probe Kit. Connect the ground lead as close to the point of measurement as possible.

CAUTION

For measurements where absolute accuracy is required, one of the following probe tips or adapters must be used:

11073A	Pen-Type Probe
11072A	Isolator Tip
11061A	10:1 Divider
11063A	50 Ohm Tee

For relative measurements with the same source resistance the bare probe may be used to achieve higher input impedance.

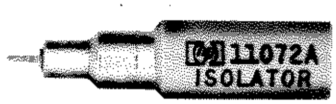
3-12. The maximum input voltage with any probe tip except the 10:1 divider is 30 V p-p AC or 100 V DC. An AC Signal, up to 5 V peak, superimposed on a DC level of 100 V may be measured if desired.

CAUTION

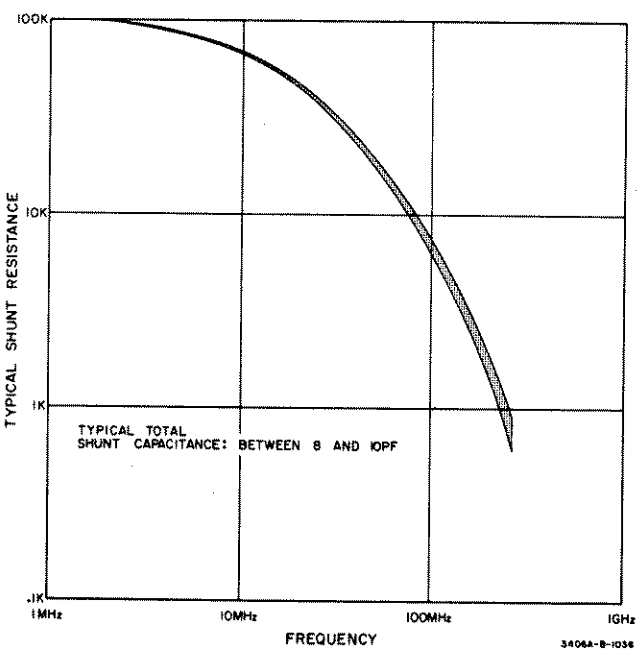
MEASURING AN AC VOLTAGE SUPERIMPOSED ON A DC LEVEL GREATER THAN 100 V MAY RESULT IN PROBE DAMAGE.

3-13. 11072A ISOLATOR.

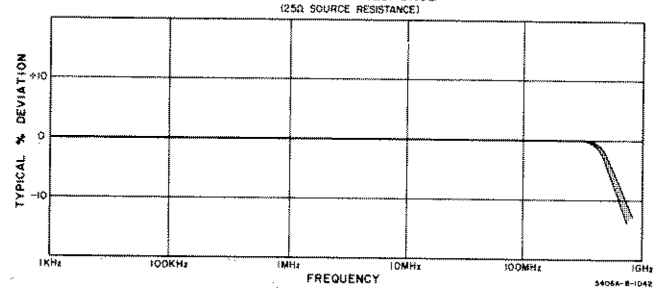
3-14. The 11072A Isolator essentially eliminates effects of source impedance variations. Total input capacitance with Isolator Tip is less than 10 pF. Recommended frequency range is 10 kHz to 250 MHz. The frequency response and input impedance with Isolator Tip is shown below. For explanation of why the Isolator Tip is necessary and how it works see Paragraph 4-14.



HP 11072A
ISOLATOR IMPEDANCE



HP11072A ISOLATOR
FREQUENCY RESPONSE
(25Ω SOURCE RESISTANCE)



3-15. 11063A 50 OHM TEE.

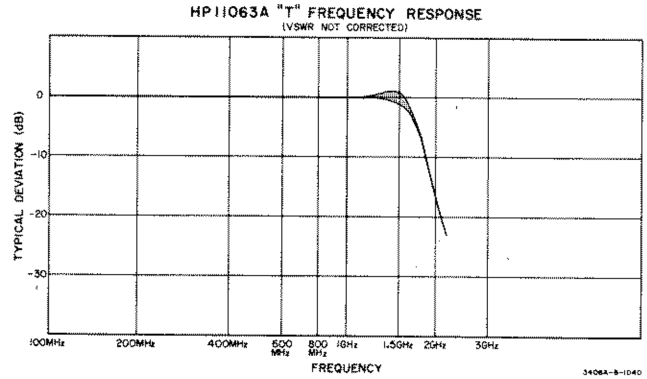
3-16. The 11063A tee is used whenever measurements are made in 50 ohm systems.

VSWR: less than 1.15 up to 1 GHz (bare probe in tee)
Insertion Power Loss: less than 1 dB up to 1 GHz

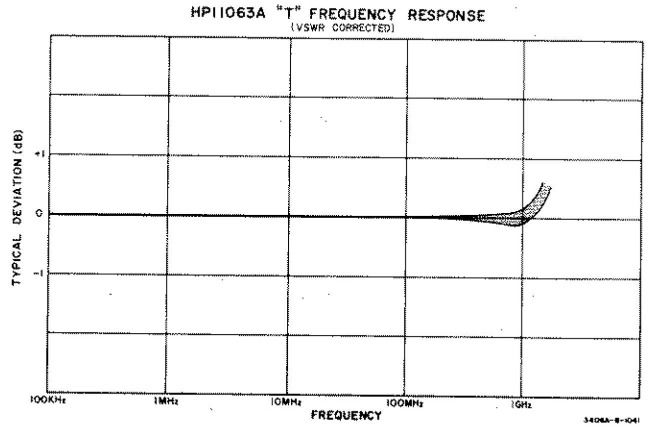
NOTE

The following curves apply only with the bare probe inserted in the tee. The frequency response of the tee with 10:1 divider is given in curve under Paragraph 3-18.

HP11063A "T" FREQUENCY RESPONSE
(VSWR NOT CORRECTED)



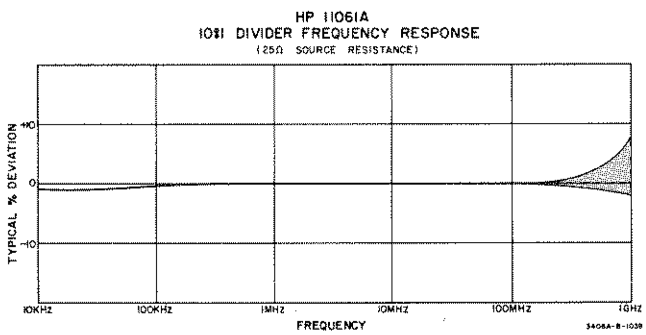
HP11063A "T" FREQUENCY RESPONSE
(VSWR CORRECTED)

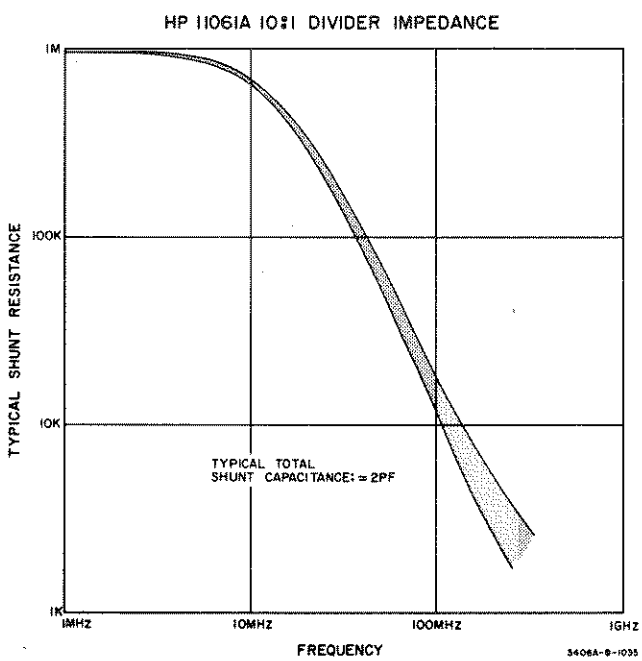


3-17. 11061A 10:1 DIVIDER.

3-18. The 11061A 10:1 Divider eliminates the effects of source impedance variations as well as divides the input voltage by a factor of ten.

Division Accuracy:	± 5% 1 kHz to 400 MHz ± 12% 400 MHz to 1 GHz
Max Input:	150 V p-p 600 Vdc





3-19. 11073A PEN TYPE ISOLATOR.

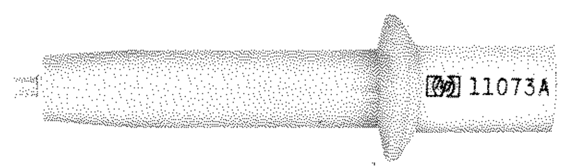
3-20. The 11073A Pen Type Isolator has a built-in isolator to eliminate the effect of source impedance variations. Various attachments to the Pen Type Isolator facilitates point-to-point measurements. The recommended frequency range is 10 kHz to 50 MHz. The added input capacitance with Pen Type Isolator is less than 8 pF. One of the following accessory tips must be used with the Pen Type Isolator:

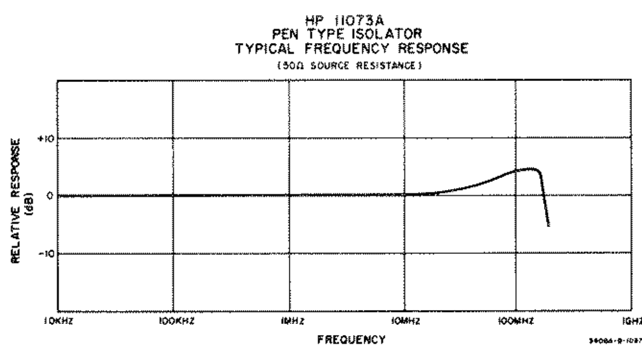
- Alligator Clip
- Pincer Jaw
- Pin Tip
- Hook Tip
- Spring Tip
- Banana Tip

} See Figure 1-3

—NOTE—

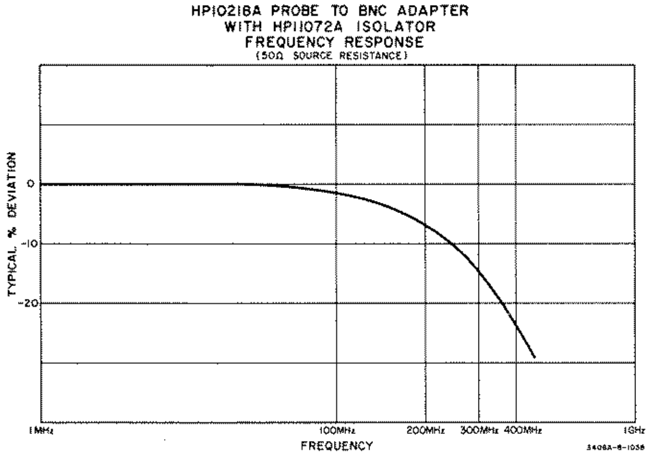
Use the alligator clip to ZERO and CALIBRATE the voltmeter when the Pen Type Isolator is used. After performing the ZERO and CALIBRATE procedure with the alligator clip any one of the six Pen Type Isolator accessories identified above may be used. Remove the plastic insulator on the front of the probe before attaching the Pen Type Isolator.





3-21. 10218A PROBE TO MALE BNC ADAPTER.

3-22. The 10218A Adapter is used to connect the probe to a female BNC connector. The recommended frequency range is 10 kHz to 250 MHz. To eliminate the effect of source impedance variations the Isolator Tip (11072A) is used with the Probe-to-BNC Adapter. The frequency response of the 10218A Adapter with the Isolator Tip is shown below.

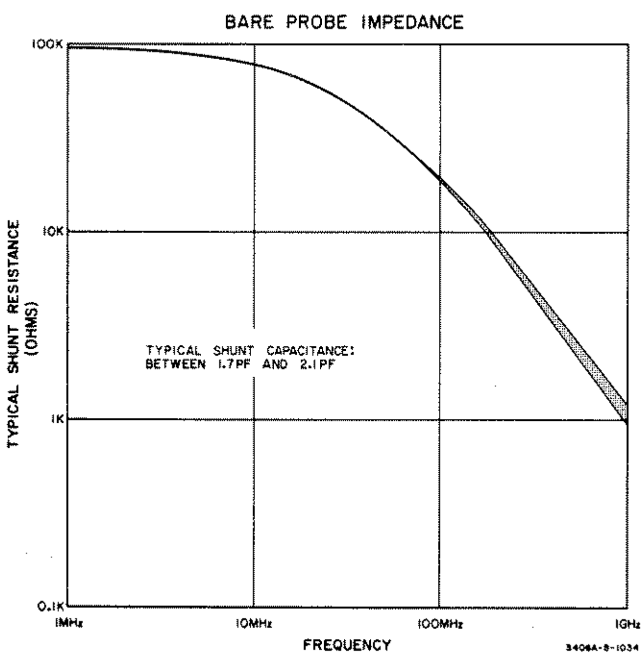


3-23. THE BARE PROBE.

3-24. The bare probe may be used for relative measurements with same source resistance. For example, checking the frequency response of a tuned tank circuit or the gain of IF stage. A higher input impedance is obtained with the bare probe.

CAUTION

TO PROTECT THE PROBE TIP WHEN THE INSTRUMENT IS NOT IN USE, INSERT THE PROBE INTO THE 1 VOLT RECEPTACLE WITH THE CAL PUSHBUTTON RELEASED.



3-25. PROBE TIP REPLACEMENT.

3-26. When replacing the probe tip on the bare probe, use the nut driver (-hp- Part No. 8710-0084) furnished with the instrument. Additional probe replacement tips may be purchased under -hp- Part No. 5020-0457.

CAUTION

WHEN REPLACING THE PROBE TIP DO NOT APPLY EXCESSIVE TORQUE; OTHERWISE DAMAGE TO COMPONENTS WITHIN THE PROBE ASSEMBLY WILL RESULT.

3-27. ZERO AND CAL THE PROBE TIP ACCESSORIES.

3-28. After selecting the proper probe tip, it is necessary to compensate the meter indication to the probe tip by performing the following procedure per probe tip or adapter selected.

a. 11063A 50 Ohm Tee: When the 50 Ohm Tee is used, remove the Isolator Tip (11072A) and perform the ZERO and CALIBRATE procedures outlined in Paragraphs 3-8 and 3-9 with the bare probe inserted into the 1 VOLT receptacle. After performing the ZERO and CALIBRATE procedures, connect the 50 Ohm Tee into circuit to be measured, and insert the bare probe into the 50 Ohm Tee. The 50 Ohm Termination (-hp- Part No. 0950-0090) is used to terminate the Tee into 50 ohms.

b. 11061A 10:1 Divider Tip: When using the 10:1 Divider Tip, remove the Isolator Tip (11072A) and perform the ZERO and CALIBRATE procedures, outlined in Paragraphs 3-8 and 3-9, with the 10:1 Divider Tip attached to the probe, and the 0.1 volt RANGE pushbutton depressed.

c. 10218A BNC Adapter: The BNC Adapter is used in conjunction with the Isolator Tip (11072A). Perform the ZERO and CALIBRATE procedures outlined in Paragraphs 3-8 and 3-9 before attaching the BNC Adapter to the Isolator Tip.

d. 11073A Pen-Type Probe: The Pen-Type Probe has a built-in isolator. To ZERO and CALIBRATE the Pen-Type Probe perform the steps outlined in Paragraphs 3-8 and 3-9 with the alligator clip attached to the Pen-Type Probe. After performing the ZERO and CALIBRATE procedures with the alligator clip, any one of the six pen probe attachments identified below may be used.

1. Alligator Clip
2. Pincer Jaw
3. Pin Tip
4. Hook Tip
5. Spring Tip
6. Banana Tip

e. 10219A Type 874A Adapter: The Type 874A Adapter is used in conjunction with the Isolator Tip (11072A). Perform the ZERO and CALIBRATE procedures outlined in Paragraphs 3-8 and 3-9 before attaching the Type 874A Adapter to the Isolator Tip.

f. 10220A Microdot Adapter: The Microdot Adapter is used in conjunction with the Isolator Tip (11072A). Perform the ZERO and CALIBRATE procedures outlined in Paragraphs 3-8 and 3-9 before attaching the Microdot Adapter to the Isolator Tip.

3-29. METER HOLD.

3-30. The Meter Hold Pushbutton (10) located on the Probe Assembly retains the meter indication for a minimum of 15 seconds when depressed. The meter Hold Pushbutton is used when making measurements in an awkward position where it is difficult to place the probe in the circuit under test and at the same time read the meter indication.

3-31. APPLICATIONS.

3-32. The Model 3406A Broadband Sampling Voltmeter is equipped with a RECORDER and SAMPLE HOLD OUTPUT in addition to the average responding direct reading rms meter. A few applications of both the RECORDER and SAMPLE HOLD OUTPUT are listed in the following paragraphs.

3-33. SAMPLE HOLD OUTPUT.

3-34. The SAMPLE HOLD OUTPUT is located on the rear panel of the instrument. A signal statistically equivalent to the input signal being measured is made available at this output. The frequency of the SAMPLE HOLD OUTPUT is within the audio spectrum, even for input signals above 2 GHz. Examples of statistically equivalent signals for three separate input signals are illustrated in Figure 3-2.

3-35. The accuracy of the SAMPLE HOLD OUTPUT is the same as the full-scale accuracy of the meter indication on the 0.01 V RANGE and above. On the 0.001 V or 0.003 V RANGE the value of input signal can be computed by taking into account the residual noise of the instrument as outlined in Paragraph 3-36 step c.

3-36. When using the SAMPLE HOLD OUTPUT the following conditions must be observed:

a. The crest factor of the input signal must not exceed 20 dB (10:1) on the 0.001 to 0.3 volt RANGE, 13 dB (4.46:1) on the 1 VOLT RANGE, and 3 dB (1.41:1) on the 3 VOLT RANGE.

b. The SAMPLE HOLD OUTPUT is valid only when the probe is connected to the circuit under test. The Meter Hold Pushbutton has no effect on the SAMPLE HOLD OUTPUT.

c. When using the SAMPLE HOLD OUTPUT to measure true rms on the .003 or .001 volt RANGE, it becomes necessary to calculate the true rms value of the input signal because of the noise present on the .003 or .001 volt RANGE using the following formula:

$$E_{rms} = \sqrt{E_s^2 - E_n^2}$$

where: E_n = Noise measured on the 3400A connected to the SAMPLE HOLD OUTPUT with the 3406A input shorted to ground and RANGE set on .003 or .001 volts.

NOTE

To ground the 3406A input, insert the probe into the 1 VOLT receptacle with the CAL pushbutton released.

E_s = 3400A indication with the input signal to be measured applied to the 3406A input.

3-37. SAMPLE HOLD OUTPUT MEASUREMENTS.

a. True RMS Measurements:
The SAMPLE HOLD OUTPUT may be used to measure the true rms value of the input signal on a True RMS Voltmeter such as the Hewlett-Packard Model 3400A. A true rms measurement may be made on any recurring waveforms within the frequency range of the Model 3406A.

NOTE

The SAMPLE HOLD OUTPUT voltage is always 0.316 volts at full-scale on all ranges because of the location of the SAMPLE HOLD OUTPUT terminal in the 3406A (refer to Block Diagram, Figure 4-4). Therefore, set the voltmeter connected to the SAMPLE HOLD OUTPUT on the 0.3 volt range and use the RANGE setting of the 3406A to determine the proper reading of the voltmeter attached to the SAMPLE HOLD OUTPUT.

b. Peak or Peak-to-Peak Measurements:
The SAMPLE HOLD OUTPUT may be used to measure the peak or peak-to-peak value of the input signal on a low frequency oscilloscope such as the Hewlett-Packard Model 130C.

NOTE

The SAMPLE HOLD OUTPUT voltage is always 0.316 volts at full-scale on all ranges because of the location of the SAMPLE HOLD OUTPUT terminal. Therefore, to determine the proper peak or peak-to-peak value of the input signal on an oscilloscope, use the settings identified in Table 3-1.

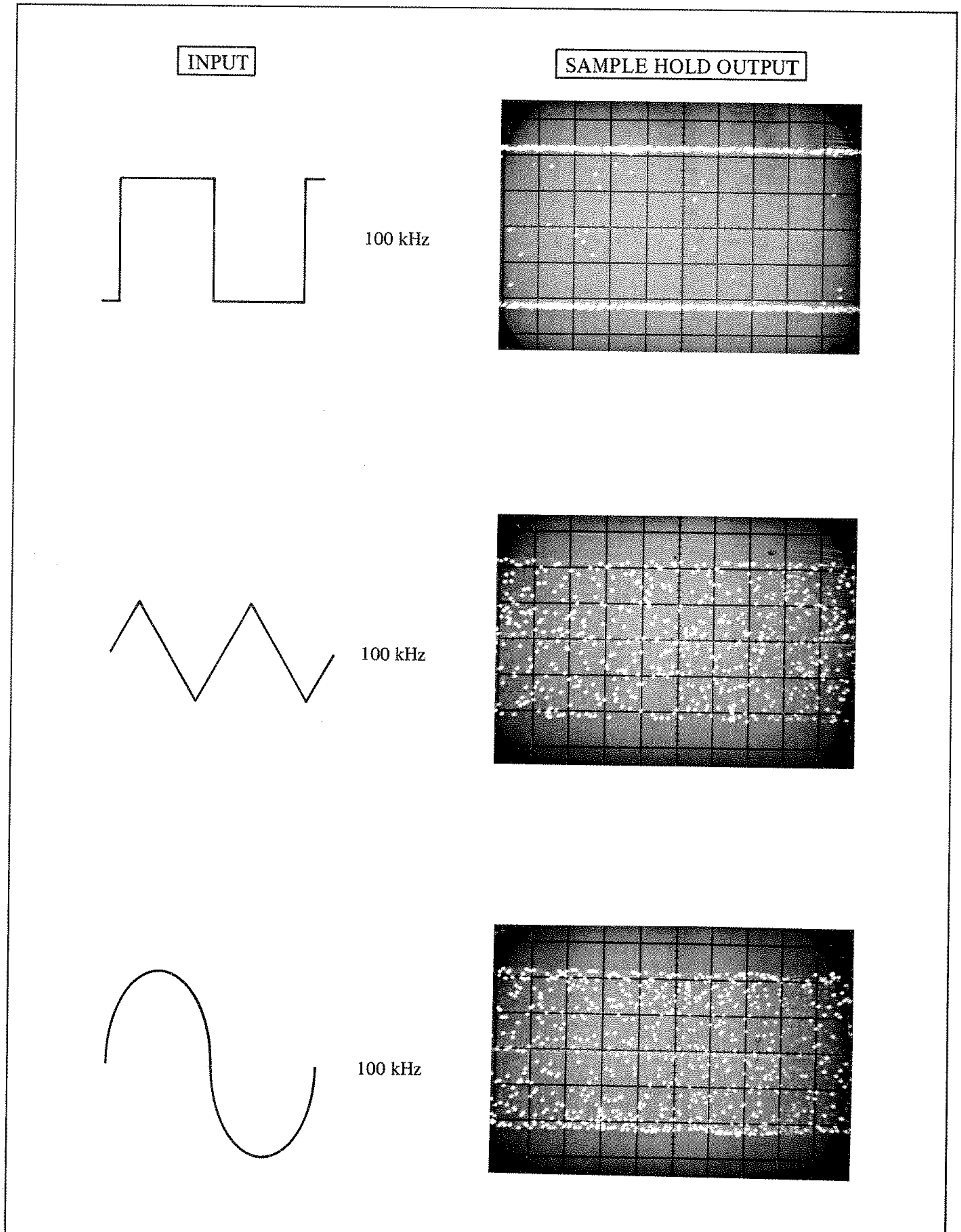
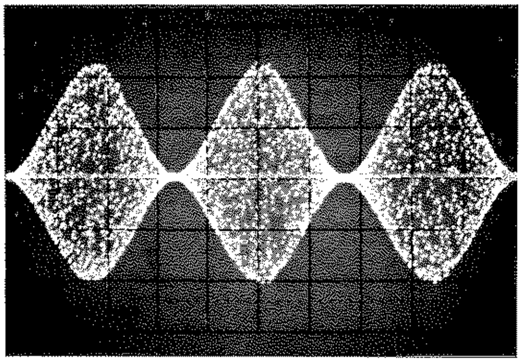
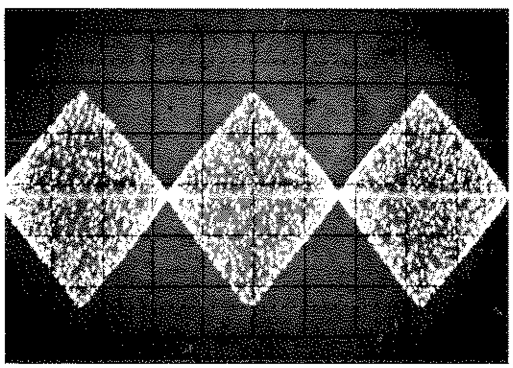


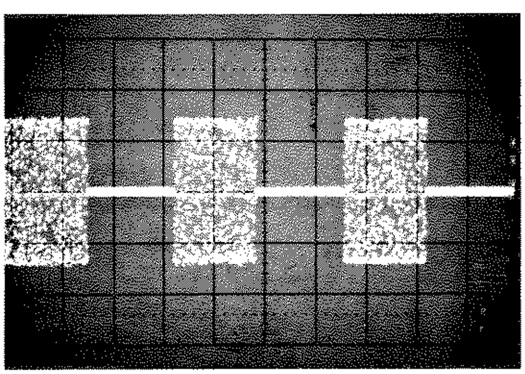
Figure 3-2. Statistically Equivalent Signals



65 MHz
CARRIER AMPLITUDE
MODULATED WITH
A SINE WAVE



65 MHz
CARRIER AMPLITUDE
MODULATED WITH
A TRIANGLE WAVE



65 MHz
CARRIER AMPLITUDE
MODULATED WITH
A SQUARE WAVE

Figure 3-3. Amplitude Modulated Signals

Table 3-1. Oscilloscope Settings

3406A RANGE	SAMPLE HOLD OUTPUT GAIN	SAMPLE HOLD OUTPUT (full scale)	OSCILLOSCOPE VERT. SENSITIVITY	
			ACTUAL SETTING	WITH RESPECT TO INPUT SIGNAL
3 Volt	0.105	0.316 Volts	.1 V/cm	1 V/cm
1 Volt	0.316	0.316 Volts	.1 V/cm	.33 V/cm
.3 Volt	1.05	0.316 Volts	.1 V/cm	.1 V/cm
.1 Volt	3.16	0.316 Volts	.1 V/cm	.033 V/cm
.03 Volt	10.5	0.316 Volts	.1 V/cm	.01 V/cm
.01 Volt	31.6	0.316 Volts	.1 V/cm	3.3 mV/cm
.003 Volt	105	0.316 Volts	.1 V/cm	1 mV/cm
.001 Volt	316	0.316 Volts	.1 V/cm	.3 mV/cm

c. Recovering Amplitude-Modulated Signals:
The SAMPLE HOLD OUTPUT may be used to monitor an AM signal with a carrier frequency within the frequency range of the 3406A, and a modulation frequency of DC to 1 kHz. Using this application hum modulation on a RF carrier may be observed. Examples of the SAMPLE HOLD OUTPUT for amplitude modulated signals are illustrated in Figure 3-3.

d. Measure true rms value of ac signal with dc component:
Since the 3406A is an ac device the SAMPLE HOLD OUTPUT can be used to measure only the rms value of the ac component. If it is necessary to include the rms value of the dc component when measuring a signal use the following formula:

NOTE

The frequency of the ac signal must be within the frequency range of the 3406A, and the dc component level must not exceed 100 Vdc.

$$E_{rms} = \sqrt{E_{ac}^2 + E_{dc}^2}$$

E_{ac} = SAMPLE HOLD OUTPUT voltage measured with 3400A.

E_{dc} = The dc component measured with the -hp- Model 414A, DC Voltmeter.

3-38. RECORDER OUTPUT.

3-39. The RECORDER OUTPUT on the rear panel provides a dc output proportional to meter deflection. The output current level is variable between zero and 1.2 mA into 1000 ohms at full scale. The output level is controlled by the RECORDER ADJ on the rear panel.

3-40. RECORDER OUTPUT APPLICATIONS.

3-41. The RECORDER OUTPUT is used to record measurements or drive auxiliary equipment. Two applications are as follows:

a. High frequency AC-to-DC converter:
The RECORDER OUTPUT may be used as an AC-to-DC converter for ac signals from 10 kHz to 2 GHz.

b. Leveling:
The RECORDER OUTPUT may be used to control the output level of a broadband signal generator which has a dc modulation capability and the necessary loop compensation circuits to prevent oscillations.

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains the theory of operation for the -hp- Model 3406A Broadband Sampling Voltmeter. A discussion of the sampling technique used as well as a theory of operation is given.

4-3. SAMPLING TECHNIQUE.

4-4. The -hp- Model 3406A uses a unique "incoherent" sampling technique to translate a high frequency input signal into a low frequency equivalent. This incoherent sampling used to produce the equivalent signal is illustrated in Figure 4-1 and described in the following paragraphs.

4-5. COHERENT SAMPLING.

4-6. Waveforms A and B in Figure 4-1 illustrate the coherent sampling technique commonly used in oscilloscopes to reconstruct the waveform at a lower frequency. With coherent sampling each sample is taken at a fixed frequency with the period of time between samples remaining constant as illustrated in waveform A.

4-7. Waveform B is a collection of pulses representing each sample (1 thru 12) taken on waveform A. The relative phase (order), polarity and proportional amplitude of the input signal at the point of sample are all preserved. Therefore, if a sufficient number of samples are taken a lower frequency equivalent of the input signal will be reconstructed. This lower Frequency equivalent will have the same average, peak and rms value as the original signal, waveform A.

4-8. INCOHERENT SAMPLING.

4-9. If the pulses in waveform B were "scrambled" with only the amplitude and polarity preserved a pulse train similar to waveform C may result. The pulses in waveform C, having no phase relationship with the input signal will not reconstruct the input waveform, but the statistical properties (average, peak and rms) of waveform C will be the same as waveform B. The statistical properties are the same because the same pulses are used in both waveforms. The only thing different is the order. Therefore, if a sufficient number of samples were taken in this "scrambled" fashion the resulting pulses would be statistically equivalent to the input signal with the only relative phase relationship lost.

4-10. As shown in waveform C the relative phase does not affect the statistical properties of the reconstructed pulse train; therefore, the 3406A can use a sampling technique where only the polarity and amplitude of each sample is used to determine the value of the input signal. This sampling technique is referred to as "incoherent sampling." With incoherent sampling, the interval between samples does not remain constant and the relative phase between each sample is lost as illustrated in waveforms D and E. However, the polarity and proportional amplitude of the input signal at the point of sample are still preserved; therefore, if a sufficient number of incoherent samples are taken, the average, peak and rms values of the reconstructed pulse train will be statistically equivalent to the input.

4-11. In the 3406A this statistically equivalent pulse train is amplified and applied to the SAMPLE HOLD OUTPUT for true rms or other types of measurements. The same statistically equivalent pulse train is also detected and applied to the meter circuit for a meter indication. With this reconstructed pulse train applied to the meter circuit, a small amount of meter jitter shows up. This is because the accuracy of reconstructing the input signal is proportional to number of samples taken. If an infinite number of samples could be taken, then the representation (reconstruction) of the input would be identical to the input. This, however, is impractical. Therefore, due to the finite sample rate (between 10 and 20 thousand per second) of the 3406A, there will be small movements of the meter needle (jitter) over a period of time.

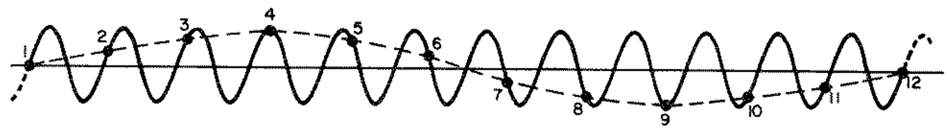
4-12. WHY INCOHERENT SAMPLING.

4-13. The 3406A uses incoherent sampling to avoid difference frequencies within the passband (0 to 10 Hz) of its metering circuit. These difference frequencies or "beat signals" could arise if the sampling frequency is held constant. For example, if the sampling frequency of the 3406A was held constant, say 10 kHz, thousands of points (frequencies) within the bandwidth of the 3406A would be harmonics of the sampling frequency. If one of these harmonics became the input signal to be measured all the samples would have exactly the same amplitude and the 3406A would see only one amplitude and one polarity (a beat signal) making it impossible to reconstruct an equivalent signal. To avoid this number in the 3406A, the sampling frequency is varied between 10 kHz and 20 kHz to produce "incoherent" sampling of the input signal.

4-14. SAMPLING EFFICIENCY.

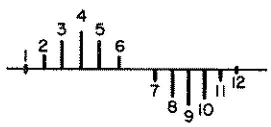
4-15. The sampling efficiency of the Model 3406A Voltmeter is determined by the source impedance of the signal being measured or the probe tip being used. Figure 4-2, illustrating the Sampling Probe Assembly A1, a source impedance Rs and a source voltage Vs, is used to explain sampling efficiency.

A



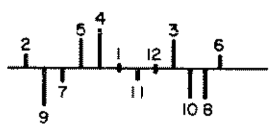
Input signal being sampled coherently.

B



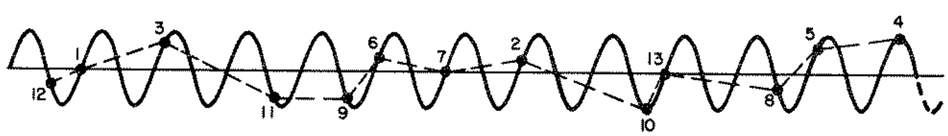
A collection of pulses reconstructing a low frequency equivalent of the input signal by preserving the height, polarity and relative phase of each sample taken.

C



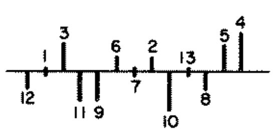
A collection of pulses "scrambled" with only the height and polarity preserved will have the same average, peak and rms values as waveform B.

D



Input signal being sampled in an incoherent fashion.

E



A collection of pulses representing the polarity and height of each sample taken incoherently. The average, peak and rms values of this waveform are the same as waveform C and B.

Figure 4-1. Sampling Technique

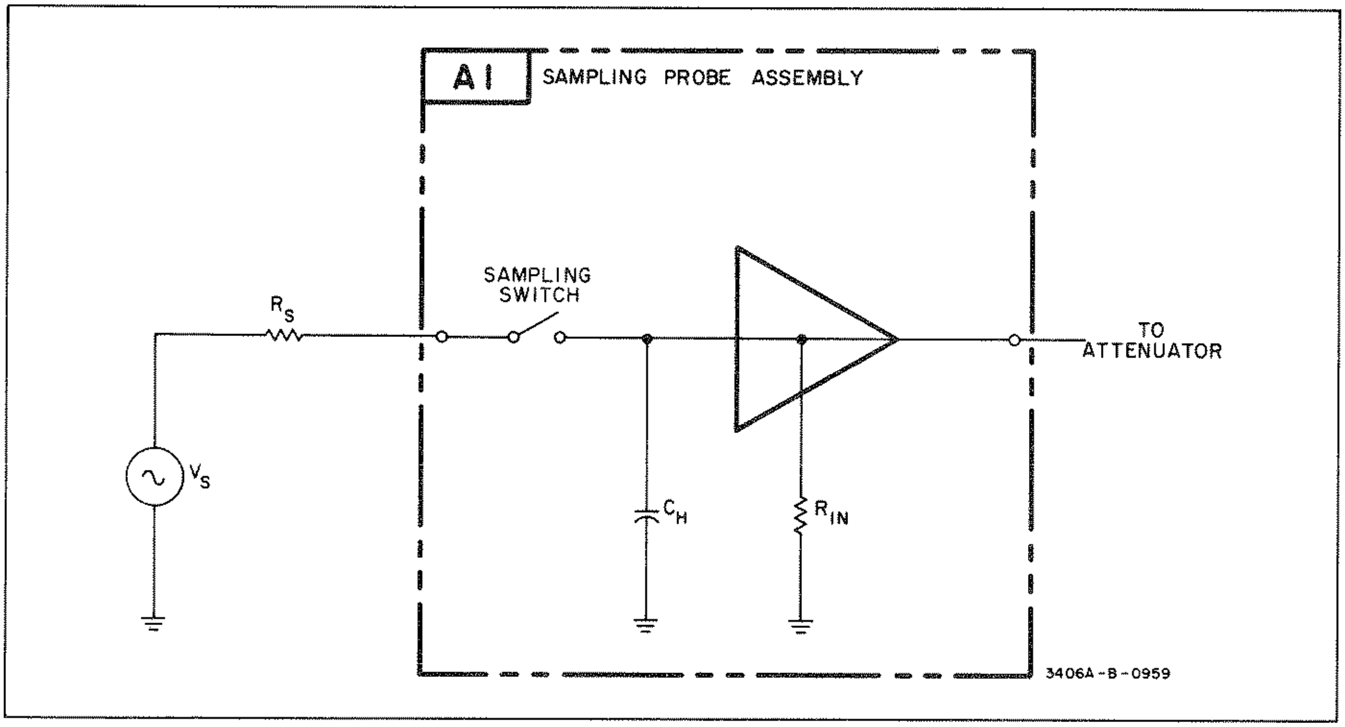


Figure 4-2. Sampling Probe Assembly

4-16. A switch within the sampling probe assembly closes for a very short period of time during each sample. When the switch closes, Holding Capacitor, Ch, will start to charge through the source resistance Rs to a value proportional to the source voltage Vs. A measurement of how close the charge on the holding capacitor Ch comes to the actual input voltage is referred to as "sampling efficiency". Therefore, sampling efficiency, in percent, can be defined by the following formula:

$$\text{Sampling Efficiency} = \frac{V_c}{V_s} \times 100$$

Where: V_c = Charge developed on capacitor during the time the switch is closed.

V_s = Actual input voltage of the source.

4-17. Since the period of time that the sampling switch remains closed is fixed (between 200 and 300 picoseconds), the source resistance Rs is the only factor determining the sampling efficiency when only the bare probe is being used. The higher the source resistance the less the charge on the holding capacitor Ch and consequently the lower the sampling efficiency. With a smaller source resistance the time constant of Rs and Ch is faster and the charge on Ch comes closer to the total source voltage Vs, and the sampling efficiency goes up. Since the charge on Ch is directly proportional to the meter deflection and SAMPLE HOLD OUTPUT level, the absolute accuracy of the voltmeter becomes a function of the sampling efficiency. This effect of source resistance on the sampling efficiency of the voltmeter is the reason that the bare probe can only be used for relative measurements with constant source resistance.

4-18. To maintain a constant sampling efficiency and eliminate the effect of varying source impedance various "isolator tips" such as the 11072A Isolator Tip, the 11073A Pen Type Isolator, the 11061A 10:1 Divider or the 50 Ohm Tee may be attached to the bare probe. These isolators compensate the effect source resistance by inserting a resistor R1 and capacitor C1 before the sampling switch as illustrated in Figure 4-3. For high source resistance (large TC for Rs - Ch) the isolator puts a capacitor C1 in parallel to aid the charge on holding capacitor Ch by discharging when the switch closes. For low source resistance (small TC for Rs - Ch) the isolator has a series resistor R1 to increase the time constant and prevent raising the percentage of charges on holding capacitor Ch. Both C1 and R1 within the isolators are selected at the factory to give a constant sampling efficiency over a wide range of source impedance. However, since the physical size and value of R1 and C1 varies between the 11072A Isolator Tip, the 11073A Pen Type Isolator and the 11061A 10:1 Divider, the actual sampling efficiency depends on the type of isolator used. For this reason a means of compensating for the difference in sampling efficiency between isolator tips is provided on the front panel.

4-19. Front panel calibrate procedure outlined in Section III adjusts the gain of the Signal Amplifier (A2Q2 thru A2Q6) to compensate for the difference in sampling efficiency between the types of isolator tips used. This is the reason the front panel CALIBRATE control must be

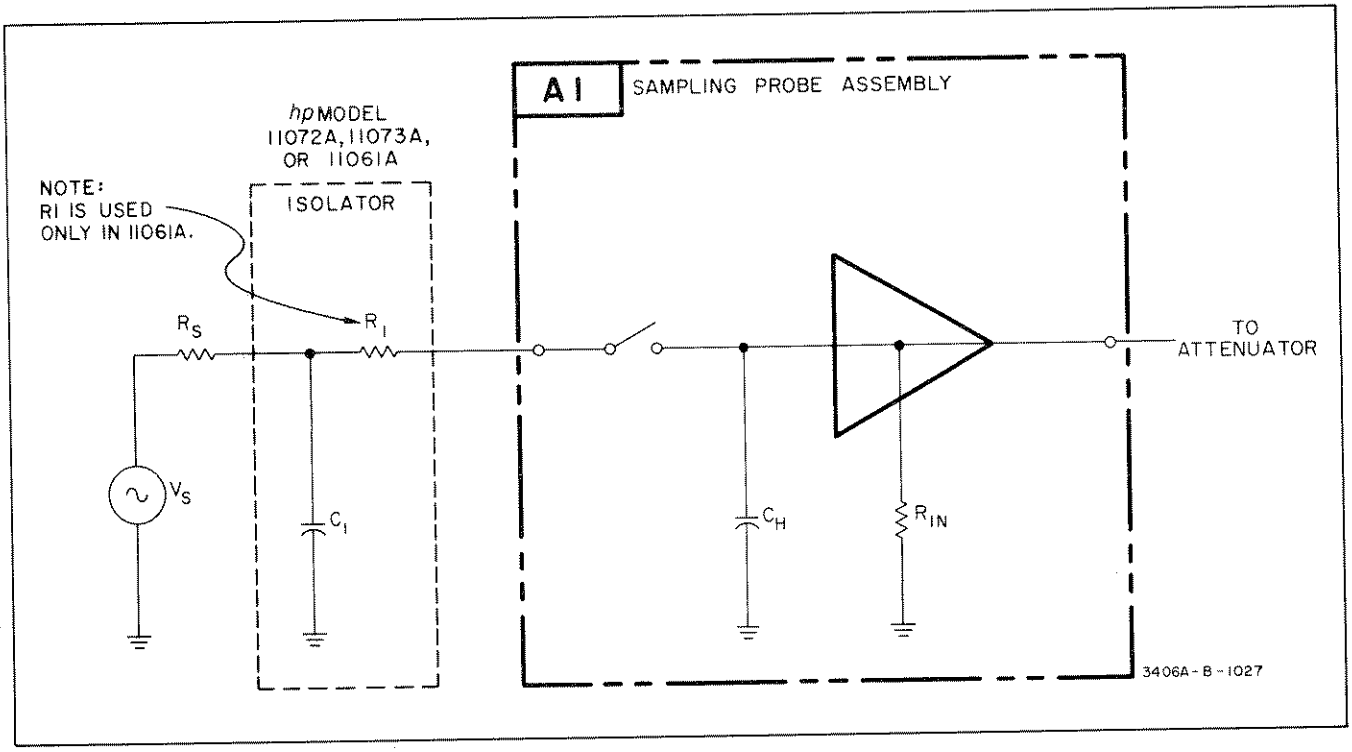


Figure 4-3. Function of Isolator Tip

adjusted each time a different probe tip is selected. Also, since the sampling efficiency of the bare probe is different than any one of the isolators, it becomes necessary to "recalibrate" the voltmeter with just the bare probe before inserting it into the 50 Ohm Tee.

4-20. GENERAL THEORY OF OPERATION.

4-21. Figure 4-4 is a block diagram illustrating the Model 3406A Broadband Sampling Voltmeter operation. All blocks shown in Figure 4-4 except the Sampling Probe Assembly and Range Control are located on two etched circuit boards (top and bottom assemblies) inside the modular cabinet of the instrument. The Sample Probe Assembly is physically located within the probe. The Range Control consists of the front panel RANGE pushbuttons and associated resistors.

4-22. Instead of continuously monitoring the input, as other RF voltmeters do, a series of samples are taken by the Sampling Probe Assembly and reconstructed into a statistical equivalent pulse train.

4-23. The input signal to be measured is applied through the appropriate probe tip to a sampling switch (see Figure 4-2) within the Sampling Probe Assembly A1. The sampling switch closes to sample the input for 200 to 300 picoseconds. The rate of closing and opening the sampling switch is controlled by Sampler Drive Pulses from the Pulse Generator p/o A3. The Sampler Drive Pulse repetition rate varies between 10 kHz and 20 kHz at a 10 Hz rate, thus producing the incoherent sampling previously discussed.

4-24. A Triangle Wave Generator and a Voltage Controlled Oscillator (all p/o A3) are used to vary the pulse repetition rate of Sample Drive Pulse. A fixed 10 Hz triangle wave from the Triangle Wave Generator is applied to the Voltage Controlled Oscillator. The voltage level of the applied triangle wave determines the output frequency of the VCO. The peak (antinode) point of the triangle wave corresponds to a 10 kHz sawtooth output and the node (0 volts) corresponds to a 20 kHz sawtooth output. Therefore, the output of the VCO becomes a sawtooth sweeping between 10 kHz and 20 kHz at the rate of the applied triangle (10 Hz). This sweeping sawtooth is applied to the Pulse Generator where a Sampler Drive Pulse is generated for each sawtooth received. Since the sawtooth is sweeping between 10 kHz and 20 kHz at a 10 Hz rate the occurance of the Sampler Drive Pulse will also vary between 10 kHz and 20 kHz at the same rate.

4-25. The Sampler Drive Pulse closes the sampling switch, and the holding capacitor Ch (see Figure 4-2) charges to a voltage proportional to the input signal. When the sampling switch reopens, after each sample, the holding capacitor completely discharges. Each charge on holding capacitor is applied to the Attenuator illustrated in Figure 4-4. Thus the sampling probe output becomes a train of pulses (one pulse per sample) whose amplitudes are directly proportional to the amplitude of the input signal at the instant the samples are taken as illustrated in Figure 4-5 waveforms A and B.

4-26. The amount of attenuation is controlled by the front panel RANGE pushbuttons. After appropriate attenuation, the pulses are amplified by the Signal Amplifier (p/o A2). Since the input signal has been translated into a lower

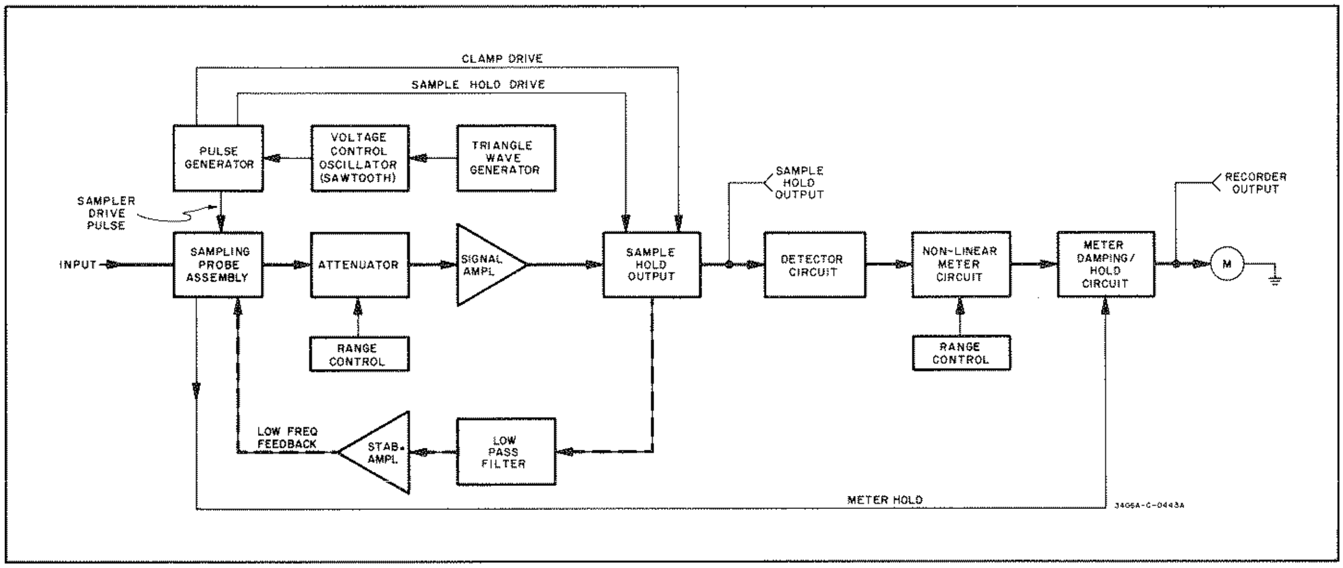


Figure 4-4. Block Diagram

frequency equivalent no high frequency compensation circuits are required in the Signal Amplifier. Three pulses from the Signal Amplifier, representing three different samples taken, are shown in Figure 4-5 waveform D. After passing through the input cable and the Signal Amplifier the sample pulses become about 5 us wide. Note, however, that the peak amplitudes of these pulses are proportional to the amplitude of the input signal at the point of sample. After the Signal Amplifier the pulses are applied to the Sample Hold Circuit.

4-27. Within the Sample Hold Circuit (p/o A2), the peak amplitude of each pulse from the Signal Amplifier is detected and held after a 2.5 usec "clamping interval" as illustrated in Figure 4-5 waveform E. Note that the peak amplitude detected is held until the next sample is initiated.

4-28. The clamping interval is the period of time (2.5 us immediately following each sample) during which the output of Sample Hold Circuit is clamped to zero volts. The clamping of each sample to zero volts establishes the dc reference level for the Signal Amplifier and the Sample Hold Output, as well as eliminating any transients that may have been caused by the Pulse Generator when the actual sample was taken.

4-29. The Clamp Drive signal from the Pulse Generator controls the starting and stopping of the clamping interval. The Clamp Drive signal is synchronized with the Sampler Drive Pulse sent to the sampling probe and occurs at the same time. Each Clamp Drive signal from the Pulse Generator, clamps the output of the Sample Hold Circuit to zero volts for 2.5 usec. During this 2.5 usec the maximum amplitude of the pulse from the signal Amplifier is reached (detected) and held as shown in Figure 4-5. The peak or maximum amplitude reached is proportional to the amplitude of the input signal at the point of sample.

4-30. The Sample Hold Drive signal, also from the Pulses Generator, is the signal that enables the Sample Hold Circuit to detect the maximum amplitude of each pulse while the output is clamped to zero volts. The Sample Hold Drive signal is also synced with the Sampler Drive Pulse and occurs at the same time.

4-31. The Sample Hold Drive signal breaks down two zener diodes, A2CR1 and A2CR2 shown in Figure 4-6, each time a sample is taken. With the two diodes conducting in reverse direction the respective pulse from the Signal Amplifier charges capacitor A2C12 to the peak value of the pulse during the 2.5 us clamping interval. The charge on capacitor A2C12 remains at this peak value even after the Sample Hold Drive and the Clamp Drive Signals are removed. This is the reason for the term "Sample-Hold". Each sample pulse is actually held at its peak amplitude until the next sample is taken, and then the Sample Hold Output is again clamped back to zero volts.

4-32. The end result of the Sample Hold Circuit is a series of square wave like pulses with amplitudes proportional to the peak amplitudes of each pulse from the Signal Amplifier, as illustrated in Figure 4-5. Note, that after a sufficient number of pulses (samples) from the Signal Amplifier, the Sample Hold Output becomes statistically equivalent to the input signal. This statistically equivalent signal is applied to the Detector Circuit and the SAMPLE HOLD OUTPUT jack on the rear panel. Refer to Section III for applications using this statistically equivalent signal available at the SAMPLE HOLD OUTPUT jack.

4-33. The Detector Circuit (p/o A2) detects the absolute average value of all the pulses from the Sample Hold Circuit. The Detector Circuit has an input-output linearity characteristic that eliminates the low level non-linear region of common rectifying type detectors. The dc output of the Detector Circuit is applied to the Non-Linear Meter Circuit (p/o A2).

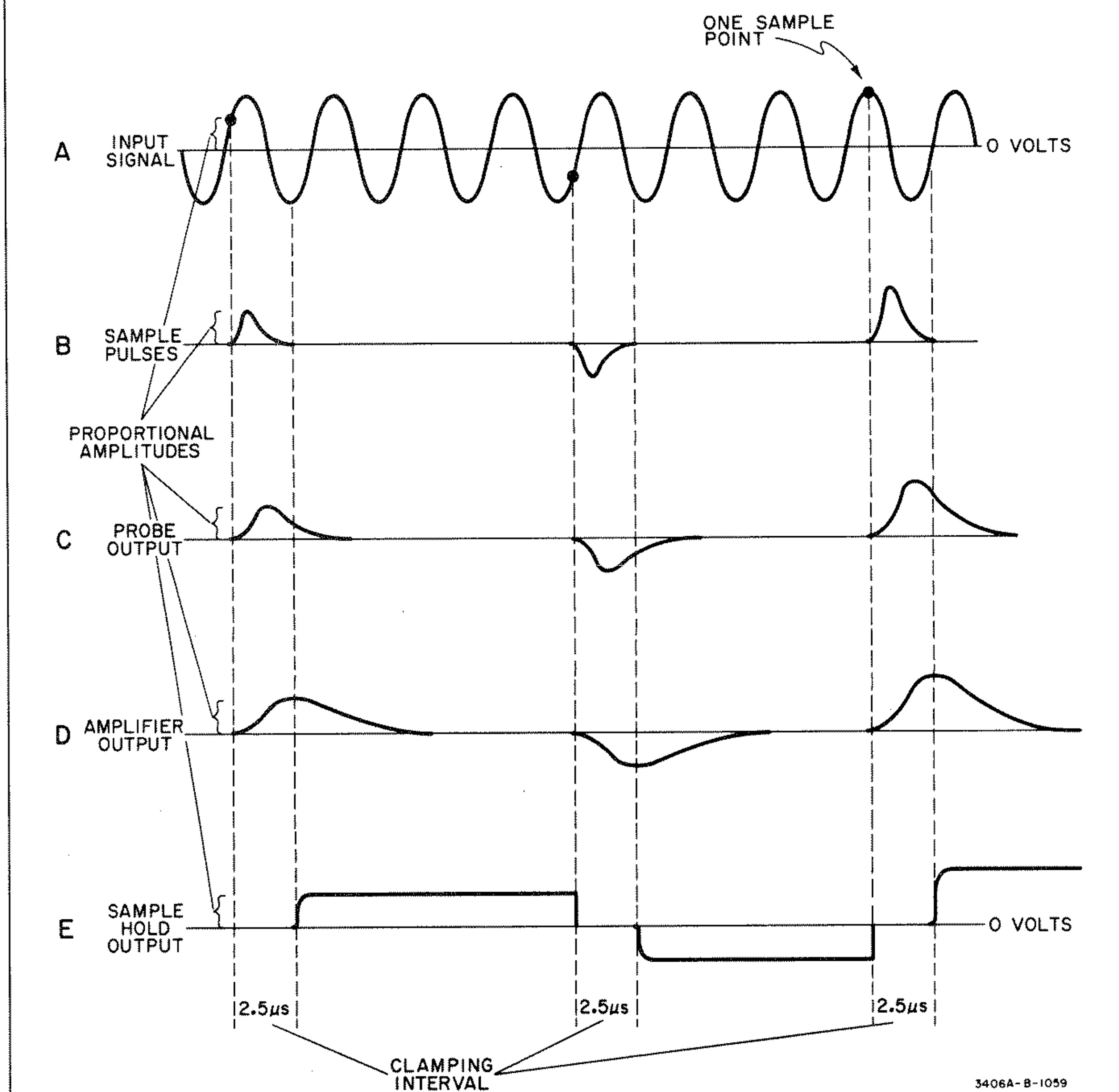


Figure 4-5. Sample Hold Output

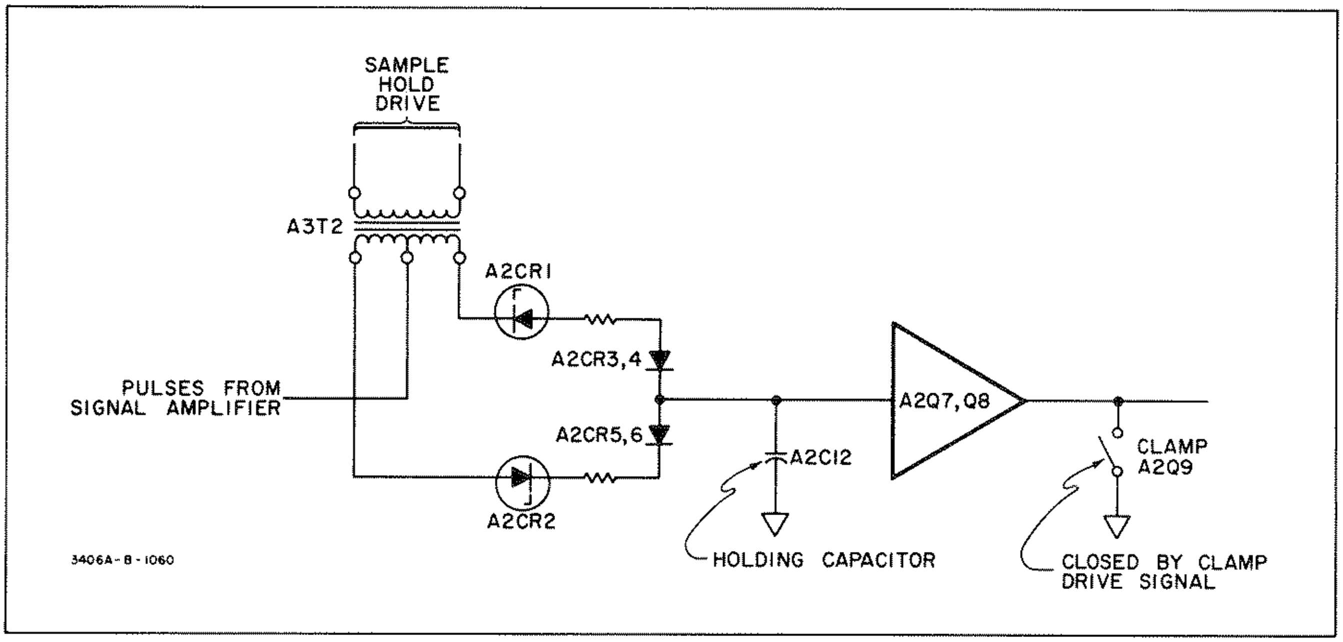


Figure 4-6. Sample Hold Circuit

4-34. Because the signal-to-noise ratio is small on the lower ranges, the noise caused by the sampling probe starts affecting the apparent gain of the detector as shown in Figure 4-7. The gain of the detector is low for small signal-to-noise ratios and approaches unity gain with larger signal-to-noise ratios. To compensate for this non-linear gain caused by the signal-to-noise ratio, a Non-Linear Meter Circuit is inserted between the detector and the final Meter Amplifier. The gain of the Non-Linear Meter Circuit is the inverse of the detector gain as shown in Figure 4-7. Therefore, the resulting gain of both circuits is unity and the effects of small signal-to-noise ratios are eliminated.

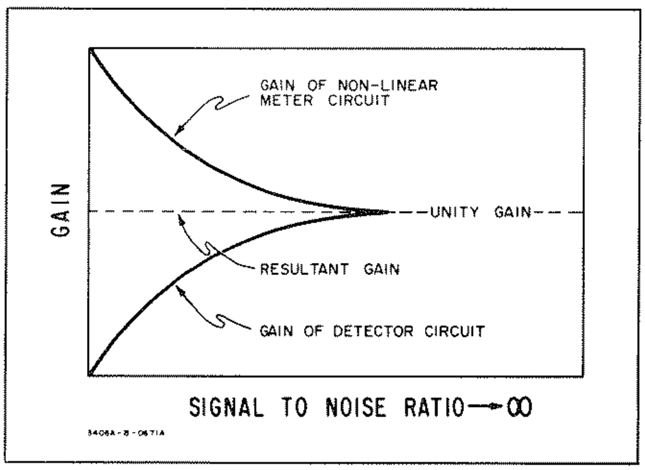


Figure 4-7. Resultant Gain

4-35. The gain of the Non-Linear Meter Circuit is controlled by negative feedback around a differential amplifier as shown in Functional Block Diagram, Figure 7-1. The amount of feedback is controlled by the front panel RANGE pushbuttons and internal "tracking" adjustments.

4-36. The output of the Non-Linear Meter Circuit is applied to the Damping/Hold Circuit. The Damping/Hold Circuit (p/o A3) impresses heavy damping on the meter movement for small changes appearing in the input voltage being measured. For large changes in input voltage, the Damping/Hold Circuit results in fast meter movements. This type of damping is used to reduce meter jitter (small meter movements) caused by the finite sampling rate of the voltmeter as described in Paragraph 4-11. The Damping/Hold Circuit also performs the meter hold operation when the pushbutton on the case of the probe is depressed.

4-37. The output of the Damping/Hold Circuit is applied to the meter, M1, for meter indication in rms, and the RECORDER OUTPUT jack on the rear panel. The RECORDER OUTPUT is used for monitoring the input signal on a dc recorder or digital voltmeter.

4-38. The Stabilizing (Stab.) Amplifier (p/o A2) and Low Pass Filter connected in the feedback path from the Sample Hold Circuit passes only low frequencies around 10 Hz and any dc drift. The Stabilizing Amplifier amplifies any dc drift and any 10 Hz component caused by the sampling frequency sweeping between 10 kHz and 20 kHz at a 10 Hz rate. The output of the Stabilizing Amplifier is applied to the Sampling Probe Assembly to stabilize the Signal Amplifier and eliminate any dc from getting into the Sample Hold Circuit.

NOTE

A Functional Block Diagram of the 3406A Voltmeter is shown in Figure 7-1. Pertinent notes and waveforms are given on this Functional Block Diagram to aid in understanding the theory of operation.

WARNING

These servicing instructions are for use by trained service personnel only. To avoid electrical shock, do not perform any servicing other than that contained in the operating instructions unless you are qualified to do so.

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	RECOMMENDED MODEL
Oscillator	Frequency Range: 10 kHz to 10 MHz	-hp- Model 652A Test Oscillator
VHF Oscillator	Output Frequency: 10 MHz to 400 MHz Output Level: 0 dBm into 50 ohm load	-hp- Model 608C VHF Signal Generator
UHF Oscillator	Output Frequency: 500 MHz to 1.2 GHz	-hp- Model 612A UHF Signal Generator
AC Voltmeter	Frequency Range: 1 kHz to 100 kHz Voltage Range: 25 mV to 1 V Accuracy: ± 1%	-hp- Model 400E AC Voltmeter
DC Null Voltmeter	Voltage Range: ± 10 mV Accuracy: ± 2%	-hp- Model 419A DC Null Voltmeter
DC Voltmeter	Voltage Range: 0 to 20 volts Accuracy: ± 1%	-hp- Model 412A Analog Voltmeter
DC Standard	Output Voltage: 1 V at 200 mA Accuracy: 0.1%	-hp- Model 740B DC Standard Differential Voltmeter
Power Meter	Frequency Range: 500 MHz to 1 GHz Power Range: - 10 dBm Accuracy: 0.5%	432A/478A Power Meter/ Thermistor Mount
Thermal Converter	Frequency Range: 10 kHz to 100 MHz	-hp- Model 11050A Option 02
Bucking Supply	BT1: 1.34 V battery, mercury R1: 50 ohm variable ± 10% R2: 100 ohm variable ± 10% 20-turn R3: 6500 ohm ± 1%	Mallory RM-42R -hp- Part No. 2100-0002 -hp- Part No. 2100-0973 -hp- Part No. 0811-0392
Slide Screw Tuner	Frequency Range: 500 MHz to 1.2 GHz Impedance: 50 ohms	-hp- Model 872A Coaxial Slide Screw Tuner
Slotted Line	Frequency Range: 500 MHz to 1.2 GHz Residual SWR: less than 1.04	-hp- Model 805C Slotted Line
SWR Meter	Frequency: 1000 Hz ± 2% Range: 70 dB	-hp- Model 415E SWR Meter
Oscilloscope	Frequency Range: 50 MHz Vertical Sensitivity: .005 V/cm	-hp- Model 140A/1402A Oscilloscope
Low-Pass Filter	Cutoff Frequency: 1200 MHz	-hp- Model 360B Low-Pass Filter
Power Splitter	Impedance: 50 ohms Frequency Range: 500 MHz to 1.2 GHz	-hp- Model 11667A
3406A Accessory Kit	----	-hp- Model 11064A
Resistor	44.2 kilohms ± 1% 1/2 W	-hp- Part No. 0698-4936
Variable Line Transformer	Voltage Range: 103 to 127 V, 207 to 253 V Power Capability: 17 watts	Superior Type VC1M

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains instructions and information necessary for the maintenance of the -hp- Model 3406A Broadband Sampling Voltmeter. Included are Performance Checks, Adjustment and Calibration Procedures, Servicing Tips, and Troubleshooting Procedures.

5-3. TEST EQUIPMENT REQUIRED.

5-4. The test equipment required to perform the operations outlined in this section is listed in Table 5-1. This table includes the type of instrument required, critical specifications and recommended model. If the model recommended is not available, equipment which meets or exceeds the required characteristics listed may be substituted.

5-5. PERFORMANCE CHECKS.

5-6. The performance checks presented in this section are front panel procedures designed to compare the Model 3406A voltmeter with its published specifications (Table 1-1). These tests may be incorporated in periodic maintenance, post repair, and incoming quality control inspection. The Performance Checks should be conducted before any attempt is made to adjust or calibrate the instrument internally. During the Performance Checks, connect the Model 3406A voltmeter to the ac source through a variable power-line transformer so that line voltage may be varied ± 10% from 115 or 230 vac to assure that the instrument operates correctly at various ac line voltages.

NOTE

Before starting the Performance Checks allow a 30-minute warmup and stabilization period. ZERO and CALIBRATE the 3406A with the bare probe inserted into 1 VOLT receptacle on the front panel as outlined in Paragraphs 3-8 and 3-9. To assure elimination of RF interference and proper operating temperature both the side and top covers must be on during all Performance Checks.

5-7. If the Model 3406A does not meet the specification test limits given in the following procedures, perform the Adjustment and Calibration Procedures outlined in Paragraph 5-16.

5-8. RANGE-TO-RANGE TRACKING AND 10 kHz TO 10 MHz ACCURACY.

CAUTION

DO NOT ALLOW INPUT VOLTAGE TO THERMAL CONVERTER TO EXCEED 1.2 V RMS. OTHERWISE THE THERMAL CONVERTER MAY BE DAMAGED.

a. The following equipment is required for the check:

Oscillator (-hp- Model 652A)
DC Standard (-hp- Model 740B)
Power Splitter (-hp- Model 11667A)
DC Null Voltmeter (-hp- Model 419A)
Thermal Converter (-hp- Model 11050A Option 02)
Bucking Supply (See Table 5-1)

b. Connect the equipment as shown in Figure 5-1.

c. Adjust the dc standard for exactly 0.900 volts.

d. Adjust the bucking supply for a null indication on the null voltmeter. Do not readjust the bucking supply until step h of this check.

e. Connect the equipment as shown in Figure 5-2, using the dc standard (A) to supply the input to the power divider.

f. Increase the output of the dc standard until the null voltmeter indicates a null condition. This provides a 0.900 volt input to the thermal converter.

g. Disconnecting the thermal converter first and reconnecting it last, turn the power divider over, connecting the known 0.900 volt output to the 11063A tee and the unknown output to the thermal converter. This applies a known 0.900 volt to the 3406A.

h. Readjust the bucking supply for a null indication on the null voltmeter. Do not readjust the bucking supply for the remainder of the accuracy checks. This null condition will exist when the input to the 11063A tee is 0.900 V.

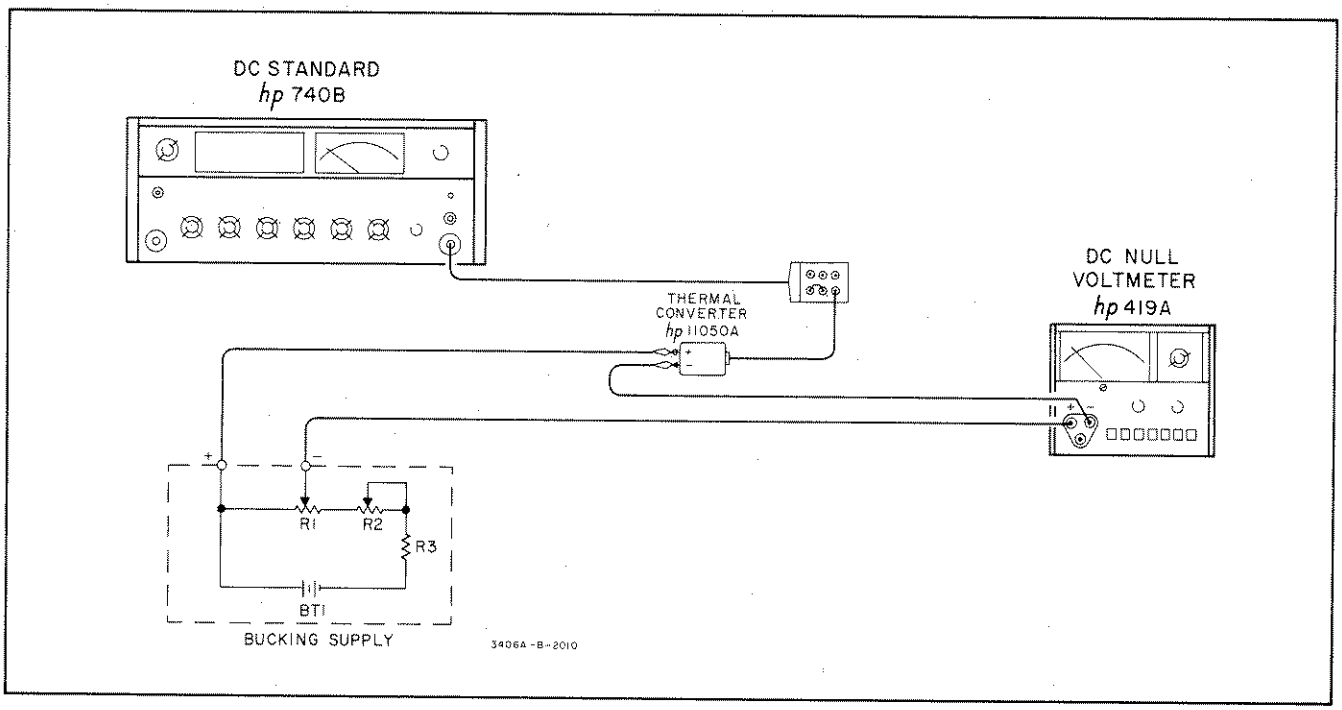


Figure 5-1. Bucking Supply Setup

NOTE

The temperature of the 50 ohm tee should be approximately equal to that of the bare probe.

i. Disconnect the dc standard and connect the oscillator (B) to the power divider. Set the oscillator frequency to 10 kHz.

j. Increase the oscillator amplitude until a null condition is indicated on the null voltmeter. Observe that the 3406A on the 1 V range indicates between 0.77 and 1.03 volts. This verifies an accuracy of ± 13% at 10 kHz.

k. Set the oscillator frequency to 20 kHz and adjust the oscillator amplitude for a null condition. Observe that the 3406A indicates between 0.82 and 0.98 volts. This verifies an accuracy of ± 8% at 200 kHz.

l. Set the oscillator frequency to 25 kHz and adjust the oscillator amplitude for a null condition. Observe that the 3406A indicates between 0.85 and 0.95 volts. This verifies an accuracy of ± 5% at 25 kHz.

m. Set the oscillator frequency to 100 kHz and adjust the oscillator amplitude for a null condition. Observe that the 3406A indicates between 0.87 and 0.93 volts. This verifies an accuracy of ± 3% at 100 kHz.

n. Repeat step m at 1 MHz and 10 MHz to verify 3% accuracy.

o. Note the exact 3406A indication at 10 MHz. Disconnect the 11063A tee from the power divider and connect the 11063A tee to the output of the oscillator. Adjust the oscillator amplitude to the exact reading noted at the beginning of this step.

p. Set a reference on the oscillator.

q. Switch the 3406A to the 3 volt range, and change the oscillator attenuator to increase the output by 10 dB (to + 20 dB setting). The 3406A should indicate between 2.76 and 2.94 volts on the 3 volt scale.

r. Decrease the oscillator output by 10 dB. The 3406A should indicate between 0.81 and 0.99 volts on the 3 volt scale.

s. Switch the 3406A to the next lowest range. The 3406A should indicate between 2.76 and 2.94 on the 3 volt scale.

t. Repeat steps r and s for all ranges of the 3406A. This verifies that range to range tracking is within the 3% accuracy specification. If the 3406A does not track properly at third scale and full scale, perform the tracking adjustment outlined in Paragraph 5-36.

5-9. 10 MHz TO 100 MHz ACCURACY CHECK.

5-10. The 10 MHz to 100 MHz accuracy check uses the following test equipment:

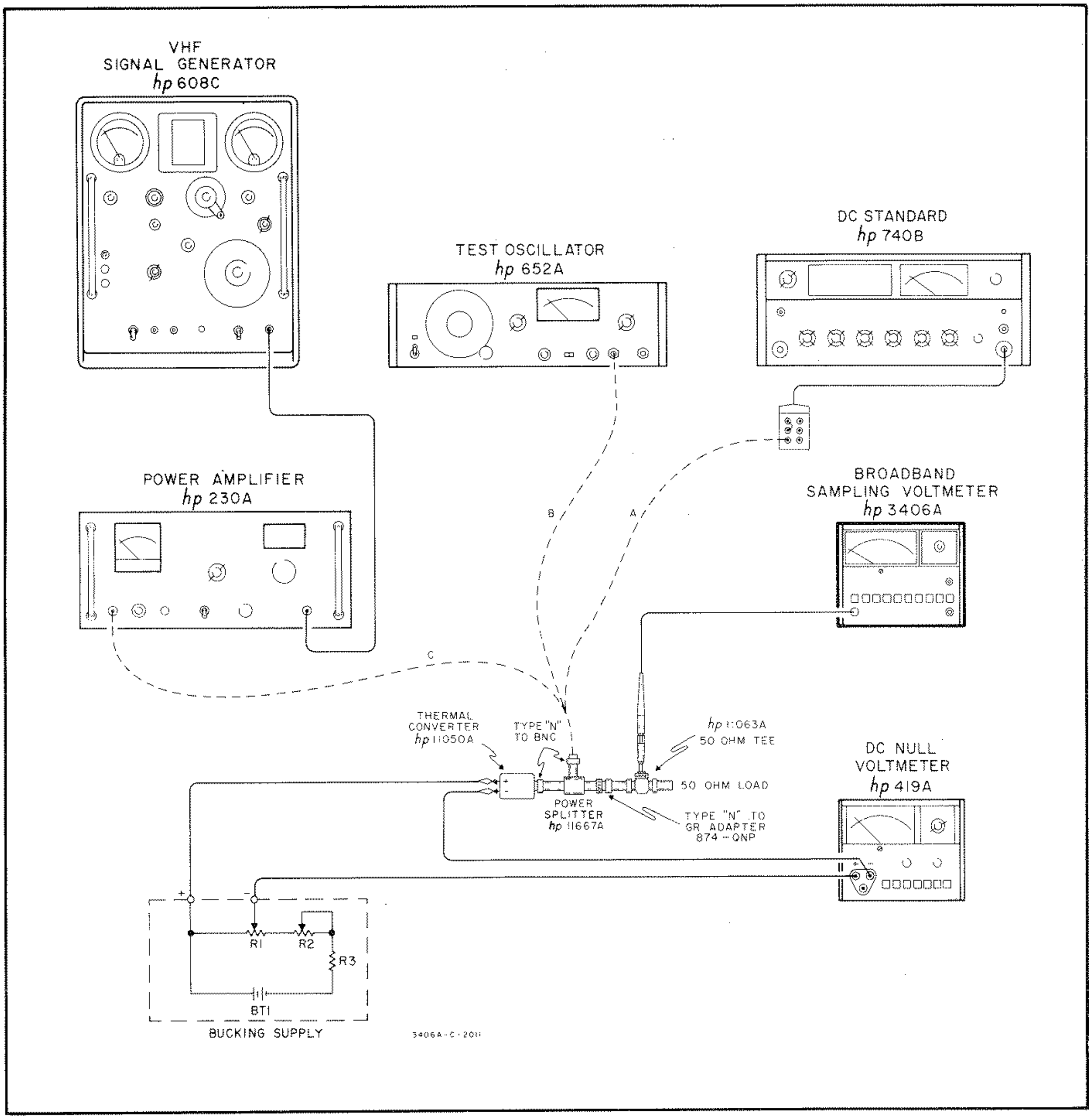


Figure 5-2. Accuracy and Range-to-Range Tracking Test Setup.

VHF Signal Generator (-hp- Model 608C)
Power Amplifier (-hp- Model 230A)
DC Null Voltmeter (-hp- Model 419A)
Power Splitter (-hp- Model 11667A)
Thermal Converter (-hp- Model 11050A Option 02)
Bucking Supply (See Table 5-1)

a. Connect the test setup as shown in Figure 5-2, using the VHF Signal Generator (C) as the signal source.

b. This check assumes the bucking supply to be adjusted as in step h of Paragraph 5-8.

c. Set the VHF signal generator to 10 MHz frequency and increase the output amplitude until a null is observed on the null voltmeter. This verifies that 0.900 volts is being applied to the 11063A 50 ohm tee. The 3406A indication should be the same as was noted in step o of Paragraph 5-8.

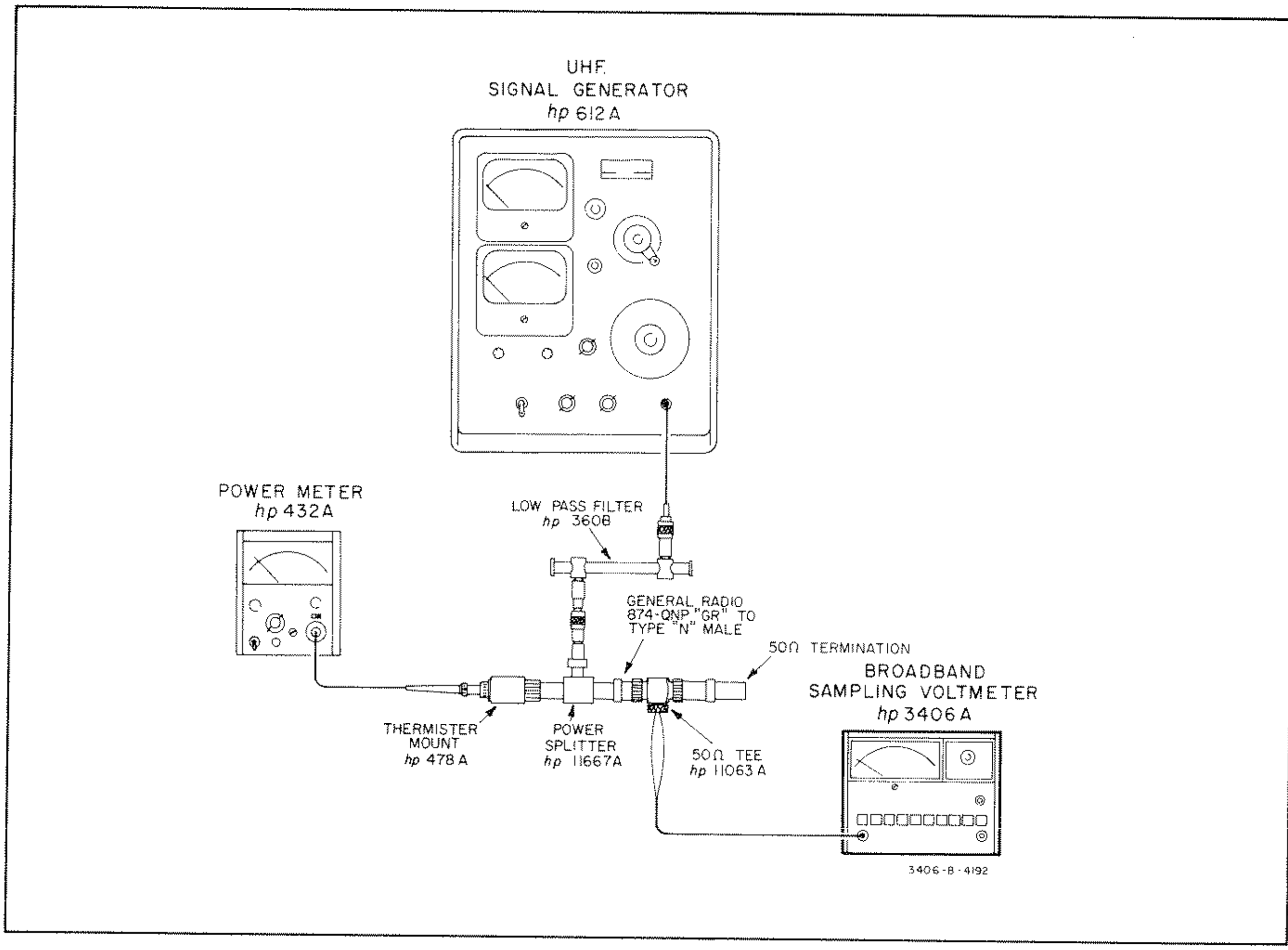


Figure 5-3. 700 MHz to 1.2 GHz Frequency Response Test Setup

d. Set the VHF signal generator frequency to 100 MHz, and adjust the output amplitude for a null indication on the null voltmeter. The 3406A should indicate between 0.87 and 0.93 volts.

NOTE

If the 3406A failed any of the preceding specification limits, perform the adjustment and calibration procedures, Paragraph 5-16.

5-11. 700 MHz TO 1.2 GHz ACCURACY CHECK.

5-12. The 700 MHz to 1.2 GHz accuracy check test setup is shown in Figure 5-3 and requires the following equipment:

Low Pass Filter (-hp- Model 360B)
Power Splitter (-hp- Model 11667A)
Thermistor Mount (-hp- Model 478A)
Power Meter (-hp- Model 432A)
UHF Signal Generator (-hp- Model 612A)
50 Ohm Termination (General Radio GR874-W50B)

a. Connect the equipment as shown in Figure 5-3.

b. Set the UHF signal generator frequency to 700 MHz.

c. Adjust the UHF signal generator output amplitude for a power meter indication of - 10 dBm.

d. The 3406A should indicate between 0.0657 and 0.0757 volts on the 0.1 volt range. This verifies an accuracy of ± 5%.

e. Set the UHF signal generator frequency to 1 GHz and repeat Step c. The 3406A should indicate between 0.0627 and 0.078 volts on the 0.1 volt range.

f. Set the UHF signal generator frequency to 1.2 GHZ and repeat Step c. The 3406A should indicate between 0.0577 and 0.0837 volts on the 0.1 volt range.

NOTE

If the 3406A failed any of the above steps, perform the adjustment and calibration procedures, Paragraph 5-16.

5-13. INPUT IMPEDANCE CHECK.

a. A test oscillator (-hp- Model 652A) and 44.2 kilohm resistor (-hp- Part No. 0698-4936) are required for this check.

b. With 11072A Isolator attached to probe, connect the Model 3406A to 50 ohm output on oscillator through the resistor as illustrated in Figure 5-4.

c. Depress Model 3406A 1 volt RANGE pushbutton. Set oscillator to 10 kHz, and adjust output for full scale deflection on 3406A meter.

d. Increase frequency of oscillator until Model 3406A indicates .707 volts. Oscillator frequency should be above 200 kHz.

NOTE

Oscillator frequency of 200 kHz indicates total input capacitance of 10 pF. Oscillator frequency of 250 kHz indicates total input capacitance of 8 pF.

e. This verifies input resistance of 100 kilohms with total shunt capacitance of less than 10 pF with the Isolator Tip attached to probe. Section III shows typical input impedance with the Isolator Tip for frequencies above 1 MHz. For relative measurements with the same source resistance the bare probe may be used to achieve higher input impedance.

5-14. METER RESPONSE TIME CHECK.

a. Depress 3406A 1 volt RANGE pushbutton and insert probe into 1 VOLT receptacle.

b. Depress 3406A CAL pushbutton and adjust CALIBRATE control for 1 volt indication on meter.

c. Depress 3 volt RANGE pushbutton and allow few seconds for meter to stabilize.

d. Depress 1 volt RANGE pushbutton and verify meter indicates 1 volt ±3% (between 0.97 and 1.03) within 3 seconds.

e. If the 3406A did not respond within 3 sec perform the meter response adjustment outlined in Paragraph 5-26.

NOTE

In the above procedures a meter jitter of ±1% of reading may be observed. This jitter (small movements of the meter needle over a period of time) is within the specification of the Model 3406A and is caused by the sampling technique used within the 3406A. Refer to Section IV for additional information.

5-15. SAMPLE HOLD OUTPUT NOISE CHECK.

a. Connect an AC Voltmeter (-hp- Model 400E) to SAMPLE HOLD OUTPUT jack on the 3406A rear panel.

b. Position AC Voltmeter range selector to 100 mV range.

c. With CAL pushbutton on 3406A released insert probe into 1 VOLT receptacle.

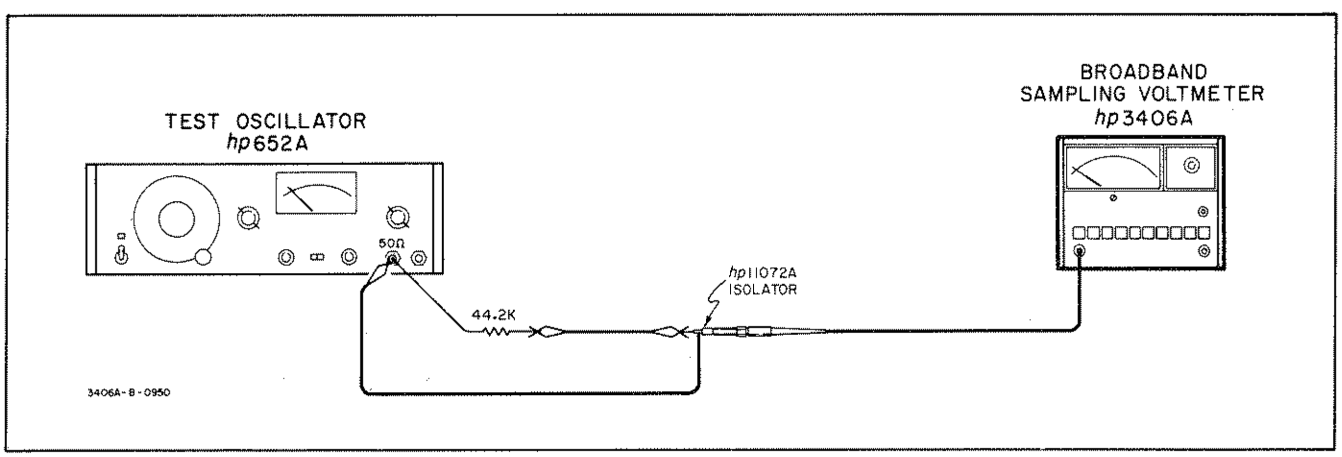
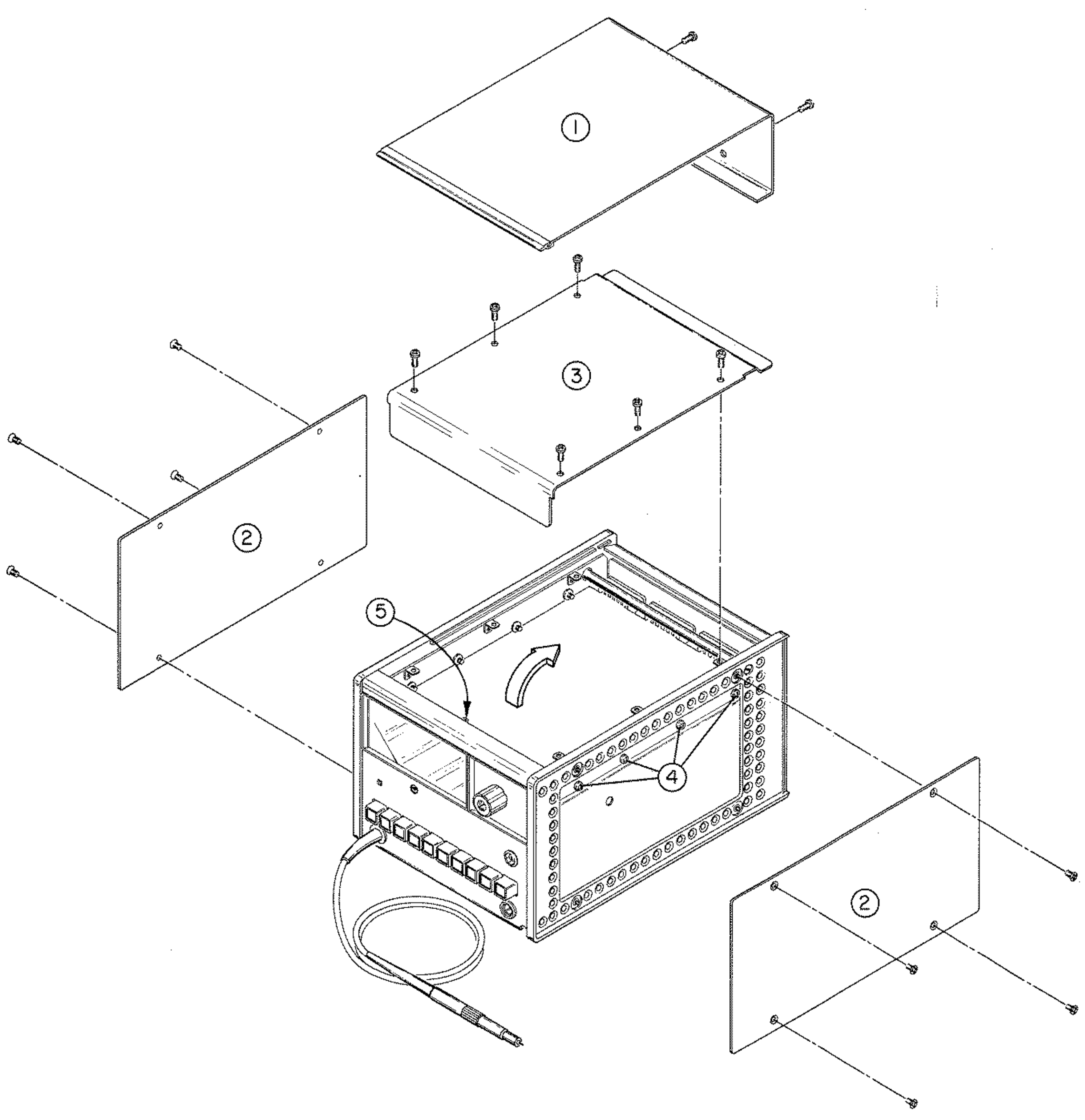


Figure 5-4. Input Impedance Test Setup



(1) Remove top cover.

(2) Remove both right and left side covers.

NOTE

The instrument is now ready for calibration and adjustment.

(3) Remove the "top shield" to make the + and - 15 V test points and Top Assembly accessible.

(4) Remove the four screws from both the right and left side gussets.

(5) Remove the front-center screw on Top Assembly.

NOTE

The "hinged chassis" may now be lifted up to make the Bottom Assembly accessible.

Figure 5-5. Preparation for Calibration or Repair

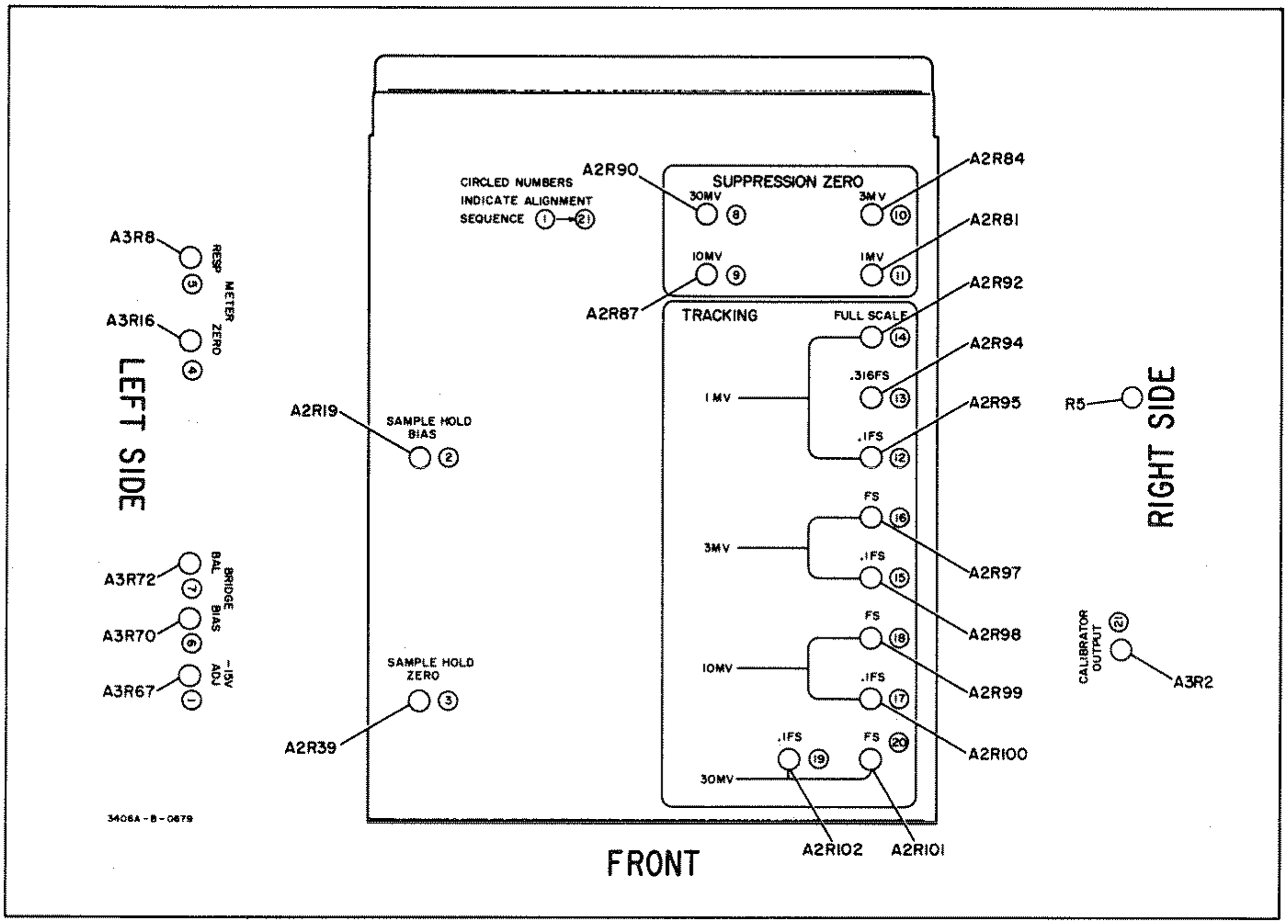


Figure 5-6. Adjust Point Location

d. Depress 3406A .001 V range pushbutton and observe meter indication of less than 55 mV on the voltmeter connected to the SAMPLE HOLD OUTPUT. This verifies the Sample Hold Output noise of less than 175 uV referred to the input.

NOTE

The Sample Hold Output voltage is 316 mV full scale for all ranges. On the 1 mV range 50 dB of gain is provided for Sample Hold Output. Therefore less than 175 uV of noise X 50 dB of gain equal less than 56 mV. See Section III for additional information concerning Sample Hold Output.

5-16. ADJUSTMENT AND CALIBRATION PROCEDURES.

The following paragraphs contain a complete adjustment and calibration procedure for the Model 3406A. This procedure should be conducted only after it has been established that the Model 3406A does not meet its published specifications. Indiscriminate adjustment of internal controls to refine readings may actually cause more difficulty. Two external adjustments, ZERO and CALIBRATE are outlined in Paragraphs 3-8 and 3-9 and should be performed prior to making any measurements or when changing the probe tip.

5-17. PREPARATION FOR CALIBRATION (COVER REMOVAL).

5-18. The 3406A is housed in a box within a box construction to eliminate RF interference. Perform the steps outlined in Figure 5-5 to prepare the instrument for adjustment and calibration.

NOTE

All adjustments are available through the top shield or side gussets as illustrated in Figure 5-6. The circled numbers indicate the alignment sequence ①-㉑. Figure 5-6 also gives the reference designator for each adjustment.

Perform steps ③ thru ⑤ in Figure 5-5 only if it is necessary to make the components or test points on the top or bottom assemblies accessible.

5-19. MECHANICAL METER ZERO.

a. Turn the instrument on and let it warm up for at least 20 minutes. Turn the instrument off after warmup and allow at least one minute for all capacitors to discharge.

b. Rotate the mechanical zero adjustment screw (Figure 3-1) clockwise until the meter pointer is to the left of zero and begins moving upscale toward zero; stop when the meter pointer is right on zero. If the pointer overshoots, continue turning clockwise and repeat the procedure in this step.

c. After aligning the meter pointer on zero, rotate the zero adjustment screw slightly counterclockwise to free the adjustment screw from the meter suspension. If the meter pointer moves during this step, repeat steps b and c.

5-20. POWER SUPPLY ADJUSTMENT.

5-21. A dc Voltmeter (-hp- Model 740B or 414A) is required for this adjustment.

a. Remove top shield, connect voltmeter between + 15 V and ground test points on Top Assembly A2. (See Figure 7-5 for Test Point location).

b. Adjust (1) - 15 V ADJ (A3R67) for + 15 volt (± .2 volts) indication on dc voltmeter.

c. Connect voltmeter between - 15 V and ground test points on Top Assembly A2.

d. DC voltmeter should indicate between - 14.6 and - 15.4 volts.

NOTE

If the power supply is not within the test limits given above perform the regulation and ripple checks outlined in Paragraph 5-57 and 5-58.

5-22. PROBE BALANCE ADJUSTMENT.

5-23. A high frequency oscilloscope (-hp- Model 140A/1402A) is required for this adjustment.

a. Connect 3406A to oscilloscope using probe-to-BNC Adapter (-hp- Model 10218A), part of 11064A Accessory Probe Kit.

b. Set oscilloscope to most sensitive vertical gain and sweep to .1 ms/cm.

c. Depress Model 3406A 3 volt RANGE Pushbutton and adjust (2) SAMPLE HOLD BIAS (A2R19) for null on oscilloscope (minimum amplitude of pulses).

d. Depress .001 volt RANGE pushbutton and adjust (7) BRIDGE BAL (A3R72) for minimum noise on oscilloscope.

NOTE

Interaction exists between adjustments (2) and (7); therefore repeat steps c and d for optimum noise on both ranges. The probe output noise must be less than 30 mV peak-to-peak.

e. Insert 3406A probe in 1 VOLT receptacle on front panel; release CAL pushbutton; set 3406A to .3 volt RANGE.

f. Connect oscilloscope to SAMPLE HOLD OUTPUT on 3406A rear panel; set oscilloscope vertical sensitivity to 0.2 V/cm and sweep to 1 ms/cm.

g. Adjust (3) SAMPLE HOLD ZERO (A2R39) for minimum amplitude pulses on oscilloscope.

5-24. METER AMPLIFIER ZERO ADJUSTMENT.

5-25. No external test equipment is required for the meter amplifier zero adjustment.

a. Remove top shield, the front, center screw on Top Assembly and lift the hinged chassis up.

b. Short A3TP2 to the ground test point located on the Bottom Assembly A3.

c. Adjust (4) METER ZERO (A3R16) for a zero reading on 3406A meter.

d. Remove short; replace center screw and shield.

5-26. METER AMPLIFIER RESPONSE ADJUSTMENT.

5-27. No external test equipment is required for the meter amplifier response adjustment.

a. Insert 3406A probe in 1 VOLT receptacle; depress CAL and 1 volt RANGE pushbuttons.

b. Adjust front panel ZERO control for 3406A meter deflection of 0.8 (reference point).

c. Release CAL pushbutton; allow 1 minute for the 3406A to stabilize.

NOTE

Meter response is properly adjusted when the meter needle moves rapidly to a point just below the reference point and then moves directly to the reference point in a few small and fast incremental steps. Misadjustment is indicated by overshoot or many incremental steps.

d. Depress CAL pushbutton; note response of meter. If misadjustment of the response is indicated, proceed with the following steps.

e. Release CAL pushbutton; allow 1 minute for the 3406A to stabilize.

f. Rotate (5) METER RESP (A3R8) a small amount in a CW direction.

g. Depress CAL pushbutton; note response of meter. If response improved from step d, repeat steps e and f. If response is worse than the response in step d, repeat steps e and f, rotating (5) METER RESP in a CCW direction.

5-28. FREQUENCY RESPONSE ADJUSTMENT.

5-29. The test setup illustrated in Figure 5-3 is required for the frequency response adjustment.

a. Set the UHF signal generator frequency to 1 GHz.

b. Adjust the UHF signal generator output amplitude for a power meter indication of - 10 dBm.

c. Note the exact reading of the 3406A on the .1 volt range.

d. Set the UHF signal generator frequency to 500 MHz.

e. Repeat Step b.

f. Adjust (6) Bridge Bias (A3R70) for a 3406A indication of 0.5% higher than the reading noted in Step c.

NOTE

Setting Bridge Bias for 0.5% high at 500 MHz ensures a better response over the entire 3406A frequency range.

g. Repeat Steps a and b, and check that the 3406A indication is within 1% of the reading in Step f.

5-30. SIGNAL AMPLIFIER GAIN ADJUSTMENT. (FRONT PANEL).

NOTE

This adjustment sets the Signal Amplifier gain, and verifies proper operation of the Sampling Probe Assembly A1, Pulse Generator p/o A3, Signal Amplifier p/o A2, and Sample Hold Circuit p/o A2. The SAMPLE HOLD OUTPUT is used because of its location in the circuit.

5-31. The test setup illustrated in Figure 5-2 is used for the signal amplifier gain adjustment. The following test equipment is required:

DC Standard, (-hp- Model 740B)
Oscillator, (-hp- Model 652A)
1 Volt Thermal Converter, (-hp- Model 11050A Opt 02)
Null Voltmeter, (-hp- Model 419A)
Bucking Supply, (see Table 5-1)
Power Divider (-hp- Model 11549A)

a. Set up the bucking supply as described in Paragraph 5-8, steps b thru h.

CAUTION

DO NOT ALLOW DC STANDARD OR OSCILLATOR OUTPUT TO EXCEED RATED INPUT OF THERMAL CONVERTER. ANY OVERLOAD MAY DESTROY THERMAL CONVERTER.

b. Disconnect the dc standard and connect the oscillator (B) to the power divider. Set the oscillator frequency to 1 MHz.

c. Adjust the oscillator amplitude until a null condition is indicated on the null voltmeter.

d. Connect an ac voltmeter to the SAMPLE HOLD OUTPUT.

e. Adjust CALIBRATE on 3406A front panel for a SAMPLE HOLD OUTPUT of 0.316 volts on ac voltmeter.

NOTE

This procedure establishes the 1 volt reference used to set the calibrator (1 VOLT receptacle) output voltage in Paragraph 5-38.

5-32. BRIDGE BALANCE ADJUSTMENT.

5-33. Because of interaction existing between adjustment (2) and (7), the BRIDGE BAL (7) was set in Paragraph 5-22. No additional adjustment is required.

5-34. METER SUPPRESSION ZERO ADJUSTMENTS.

5-35. To properly ground the probe for this adjustment, the 11063A Tee with 50 ohm termination is used.

a. Center the front panel ZERO control, and insert the 3406A probe into terminated 50 ohm tee with no source connected.

b. Depress 3406A 0.03 volt RANGE pushbutton and adjust (8) 30 MV (A2R90) for zero indication on 3406A meter.

c. Depress 0.01 volt RANGE pushbutton and adjust (9) 10 MV (A2R87) for zero indication on 3406A meter.

d. Depress 0.003 volt RANGE pushbutton and adjust (10) 3 MV (A2R84) for zero indication on 3406A meter.

e. Depress 0.001 volt RANGE pushbutton and adjust (11) 1 MV (A2R81) for zero indication on 3406A meter.

5-36. NON-LINEAR METER AMPLIFIER ADJUSTMENT. (Tracking).

5-37. An oscillator (-hp- Model 651B or 652A) and an ac voltmeter (-hp- Model 400E) are required for this adjustment.

a. Using the front panel ZERO control, zero the voltmeter on the .001, .003, .01, .03 and .1 volt RANGE with the bare probe inserted into terminated 50 ohm tee with no source.

b. Connect test setup illustrated in Figure 5-7; set oscillator output frequency to 1 MHz; and output voltage for .100 V indication on ac voltmeter, using - 10 dBm setting on the oscillator.

c. Using oscillator attenuator reduce output 60 dB; and depress 3406A .001 volt RANGE pushbutton.

d. Adjust (12) .1 FS (A2R95) for 3406A meter indication of 0.1 on 0 to 1 scale.

e. Using oscillator attenuator increase output 10 dB; adjust (13) .316 FS (A2R94) for 3406A meter indication of 1 on 0 to 3 scale (which is 0.316 of FS on 0 to 1 scale).

f. Using oscillator attenuator increase output 10 dB; adjust (14) FULL SCALE (A2R92) for 3406A meter indication of 1 on 0 to 1 scale.

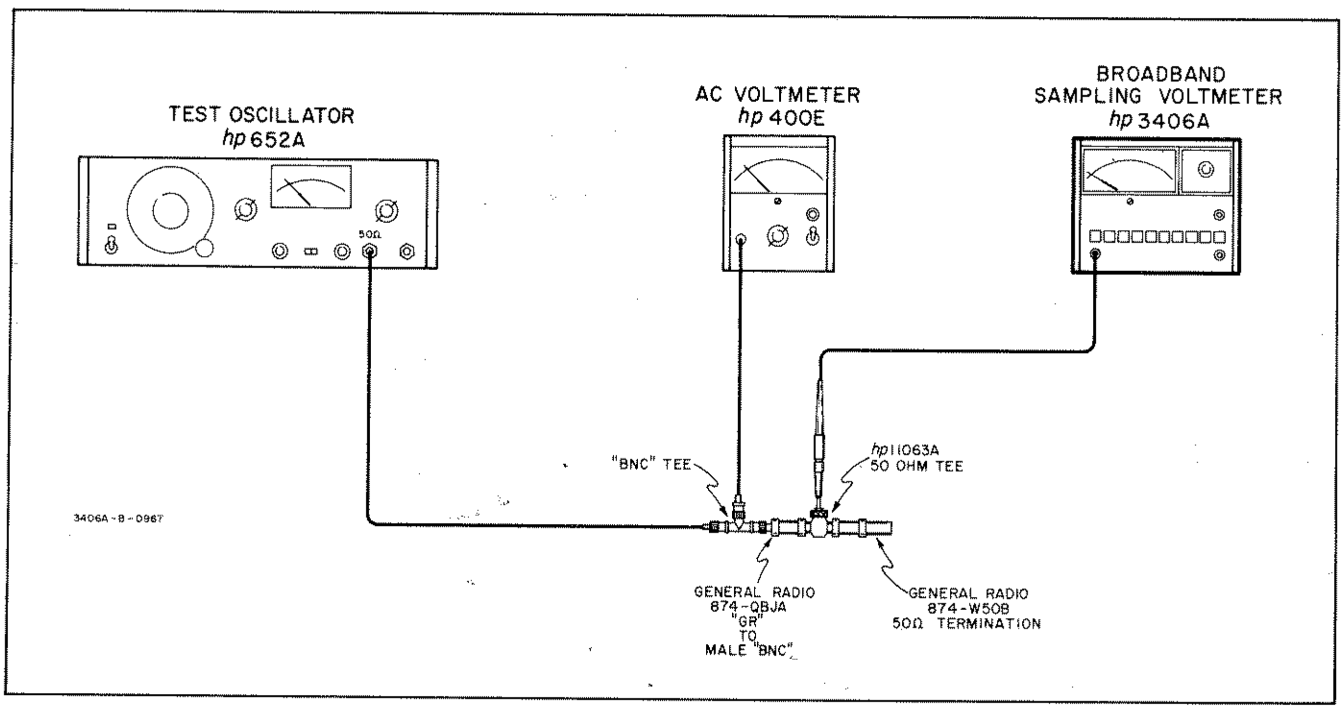


Figure 5-7. Tracking Adjustment Setup

g. Depress 3406A .003 volt RANGE pushbutton.

h. Using oscillator attenuator reduce output 10 dB; adjust (15) .1 FS (A2R98) for 3406A meter indication of 0.1 on 0 to 1 scale.

i. Using oscillator attenuator increase output 20 dB; adjust (16) FS (A2R97) for 3406A meter indication of 1 on 0 to 1 scale.

j. Depress 3406A .01 volt RANGE pushbutton.

k. Using oscillator attenuator reduce output 10 dB; adjust (17) .1 FS (A2R100) for 3406A meter indication of 1 on 0 to 1 scale.

m. Using oscillator attenuator increase output 20 dB; adjust (18) FS (A2R99) for 3406A meter indication of 1 on 0 to 1 scale.

n. Depress 3406A .03 volt RANGE pushbutton.

o. Using oscillator attenuator reduce output 10 dB; adjust (19) .1 FS (A2R102) for 3406A meter indication of 0.1 on 0 to 1 scale.

p. Using oscillator attenuator increase output 20 dB; adjust (20) FS (A2R101) for 3406A meter reading of 1 on 0 to 1 scale.

q. Depress 3406A 3 volt RANGE pushbutton and increase oscillator output by 40 dB; adjust 3 V FS (variable resistor R5 on right side of chassis) for 3406A meter reading of 1 on 0 to 1 scale. See Appendix C.

NOTE

Interaction exists between the 3 V FS adjustment and the 1 volt range. Check full scale deflection on 1 volt range and optimize adjustment of 3 V FS if necessary.

NOTE

Because of interaction between tracking and suppression zero adjustments, repeat meter suppression zero adjustment (Paragraph 5-34) and steps a thru q of this procedure until no interaction is noted between the two adjustments.

5-38. CALIBRATOR OUTPUT ADJUSTMENT.

5-39. No external equipment is required for the Calibrator Output adjustment unless the Calibrator Assembly is repaired or replaced on instruments 625-01001 and above.

NOTE

The Signal Amplifier Gain Adjustment, Paragraph 5-30, establishes the 1 volt reference used to adjust the calibrator output in the following procedure. Perform the procedure outlined in Paragraph 5-30 prior to adjusting CALIBRATOR OUTPUT.

a. Insert 3406A probe with 11072A Isolator tip in 1 VOLT receptacle on front panel; depress 1 volt RANGE pushbutton; depress CAL pushbutton.

b. Adjust (21) CALIBRATOR OUTPUT (A3R2) for 3406A meter indication of 1 on 0-to-1 scale.

NOTE

The following procedure is to be used for instruments 625-01001 and above if the Calibrator Assembly is repaired or replaced.

a. Connect 652A Oscillator into 11063A 50 Ohm Tee loaded with 50 Ohm Termination. Set 652A to 1V, 1 MHz. Remove 3406A bottom cover.

b. Insert 3406A probe with Isolator Tip into Tee and note 3406A reading.

c. Now place probe with Isolator Tip into 1 VOLT receptacle and adjust CALIBRATOR OUTPUT for same reading as in Step b.

d. Remove Isolator Tip and insert bare probe into Tee, and check for a 1V reading.

e. Now insert bare probe into 1 VOLT receptacle and adjust Allen screw on Calibrator Assembly for a 1V reading. Replace bottom cover.

5-40. SERVICING.

5-41. The Model 3406A is housed in a box within a box construction to eliminate RFI (radio frequency interference). Within the 3406A the side gussets, the "hinged chassis" and all shields have been treated with a chromate conversion coating. Chromate conversion puts a highly conductive coating on the aluminum metal to prevent oxidation, and aid in shielding against RFI. Avoid scratching the treated surface when working with the Model 3406A.

5-42. GROUNDING.

5-43. Because of the high current pulses used within the Model 3406A and RFI, proper grounding is important. Always note the location of the "ground point" before unsoldering any ground leads, and resolder any ground leads to the same "ground point".

5-44. ETCHED CIRCUIT BOARDS.

5-45. Excluding the Sampling Probe Assembly, the Model 3406A Voltmeter contains two large etched circuit boards designated Top and Bottom Assemblies. The two boards are mounted on the "hinged chassis", illustrated in Table 7-1, with 11 screws -hp- Part No. 2390-0001. An -hp- part number is silk screened on both circuit boards to identify them. See the component location diagrams in Section VII for location of each component mounted on the boards and Section VI for component replacement information.

5-46. The etched circuit boards are a plated-through type. The electrical connections between sides of the board are made with a layer of metal plated-through the component lead holes. To prevent damage to the circuit boards and components, observe the following when soldering.

a. Use a low-heat (25 to 50 watt) small-tip soldering iron, and a small diameter rosin core solder.

b. To remove a component, clip a heat sink (long nose pliers, commercial heat sink tweezers etc.) on the component lead as close to the component as possible. Place the soldering iron directly on the component lead, and pull up on the lead. If a component is obviously damaged or faulty, clip the leads close to the component and then remove the leads from the board.

CAUTION

EXCESSIVE OR PROLONGED HEAT CAN LIFT THE CIRCUIT FOIL FROM THE BOARD OR CAUSE DAMAGE TO COMPONENTS.

c. Clean the component lead holes by heating the solder in the hole, quickly removing the soldering iron, and inserting a pointed, non-metallic object such as a toothpick.

d. To mount a new component, shape the leads and insert them in the holes. Clip a heat sink on the component, heat with the soldering iron, and add solder as necessary to obtain a good electrical connection.

e. Clip excess leads off after soldering and clean excess flux from the connection and adjoining area, using type TF Freon (-hp- Part No. 8500-0232).

5-47. To avoid surface contamination the etched circuit boards may be cleaned as outlined below:

a. Clean with a solution of "Finish Dishwashing Detergent" and warm water.

b. Rinse thoroughly with clean water and immediately dry.

CAUTION

WHEN USING ANY ANTI-HUMIDITY SPRAY, THE ETCHED CIRCUIT BOARD PINS AND/OR EXTERNAL CONNECTIONS MUST BE COVERED WITH TAPE OR EQUIVALENT MATERIAL. OTHERWISE, AN INADEQUATE ELECTRICAL CONNECTION TO THE APPROPRIATE CONNECTOR WILL RESULT.

c. When completely dry and properly masked, spray lightly with "General Electric Dry Film 88" anti-humidity spray.

d. The teflon insulators in the gate circuit of the Field Effect Transistors, A2Q7 and A3Q3 should be cleaned with fine wire brush and sprayed lightly with "General Electric Dry Film 88" anti-humidity spray.

5-48. SERVICING THE PROBE ASSEMBLY.

5-49. The Sampling Probe Assembly A1 is not a field repairable item. A complete assembly is available on exchange basis (-hp- Part No. 03406-62106) through your local Hewlett-Packard Sales and Service Office. Perform the steps outlined in Paragraph 5-52 to verify proper operation of Sampling Probe Assembly before ordering replacement probe.

5-50. TROUBLESHOOTING PROCEDURES.

5-51. The following troubleshooting procedures are designed to assist in isolating a malfunction(s) within the Model 3406A voltmeter. These procedures should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures outlined in Paragraph 5-16. An investigation should also be made to ensure that the trouble is not a result of conditions external to the Model 3406A voltmeter.

NOTE

In addition to the following paragraphs, waveforms and DC voltage levels are shown on the schematic diagrams in Section VII. Use the Functional Block Diagram, Figure 7-1, to isolate the trouble to a particular block.

5-52. TROUBLESHOOTING THE PROBE ASSEMBLY.

5-53. The Sampling Probe is not a field repairable item. A complete assembly is available on an exchange basis under -hp- Part No. 03406-62103. Therefore, the first step in troubleshooting the Model 3406A is to determine if the Sampling Probe is operating properly. To verify proper operation of the probe perform the following steps:

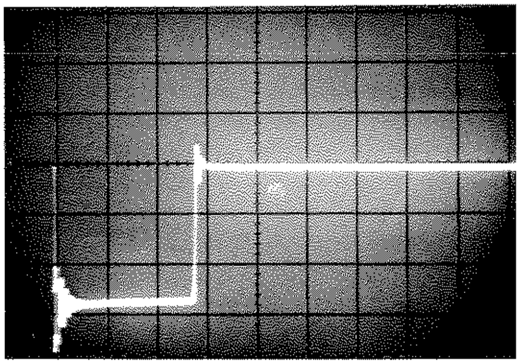
a. Insert the probe into 1 VOLT receptacle and depress CAL and 1 volt RANGE pushbuttons.

b. Remove two Phillips head screws at the rear of the bottom cover and remove the bottom cover.

c. Remove 13 Phillips head screws from the bottom shield and remove it.

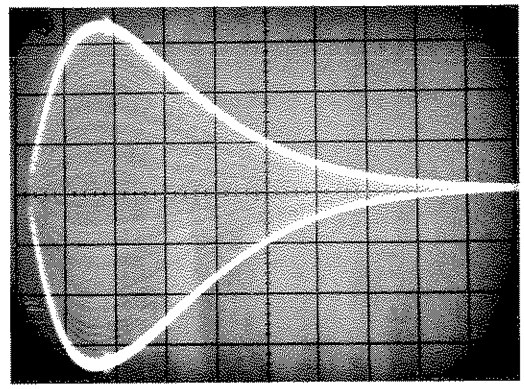
d. Remove the probe filter (FL2) shield (Refer to Figure 7-2).

A



White wire on FL2
Ac coupled
Vert = 5 V/cm
Sweep = 1 usec/cm

B



Blue wire on FL2
Ac coupled
Vert = .1 V/cm
Sweep = 2 usec/cm

NOTE

To stop the waveform from sweeping back and forth short the collector of A3Q6 on the Bottom Assembly to ground (see Figure 7-8 for location of A3Q6).

Figure 5-8. Troubleshooting the Probe

NOTE

The following identifies the function of each signal entering or leaving the Sample Probe Assembly through the Probe Filter Assembly (FL2). The color of wires connected to the feedthrough capacitors on the Probe Filter Assembly are the same on the top as they are on the bottom. (Refer to Figure 7-2).

Wire Color	Function
White	Pulse from Pulse Generator
Orange	Feedback to FET from Stabilizing Ampl
Blue	Sampling probe output
Green	Meter hold
Red	Bridge bias and balance (pos)
Brown	Bridge bias and balance (neg)
Yellow	FET drain

CAUTION

WHEN TAKING MEASUREMENTS AT THE PROBE FILTER DO NOT SHORT OUT THE WHITE WIRE. IF THE WHITE WIRE IS SHORTED DAMAGE TO THE PULSE GENERATOR WILL RESULT.

e. Connect an oscilloscope to the white wire connection on FL2 (J10 pin 6).

f. On oscilloscope observe the pulse from Pulse Generator as shown in Figure 5-8A.

NOTE

If no pulse is present check the wiring from the top of the probe filter FL2 to the Interconnecting Assembly, and troubleshoot the Pulse Generator circuit shown in Figure 7-8.

g. Connect oscilloscope to the blue wire connection on FL2, J10 pin 8, (sampling probe output).

h. Observe the "tear drop" waveform shown in Figure 5-8B.

NOTE

If the "tear drop" waveform is present the Sampling Probe is operating properly. If waveform A in Figure 5-8 (step e) is present and waveform B (step g) is not present, replace the Sampling Probe Assembly according to the following procedures.

5-54. REPLACING THE PROBE ASSEMBLY.

CAUTION

DO NOT PLUG OR UNPLUG THE PROBE FROM J10 WITH THE 3406A TURNED ON.

a. Repeat steps b, c and d in Paragraph 5-53.

b. Unplug the probe connector from its 12 pin connector J10. (See Figure 7-2).

c. Remove the cable clamp (MP17 Figure 6-2) just above the probe connector.

d. Loosen the extra-long nut (MP8 Figure 6-2) behind the front panel, and slide it off the cable. The nut is notched on the inside so that the plug on Probe Connector can fit through it.

e. Save the cable clamp and nut removed in steps c and d for installing the new probe assembly.

f. Install the new or exchange probe assembly by reversing steps d thru a. When replacing the bottom shield, it is important that all of the screws are replaced. Any open holes will degrade the RFI protection provided by the shield.

NOTE

After replacing the Probe Assembly a complete Adjustment and Calibration is required as outlined in Paragraph 5-16.

5-55. TROUBLESHOOTING THE POWER SUPPLY.

NOTE

For Serial Numbers 1234A0440 and above, if failure occurs in any portion of the line filter; i.e., 03406-01206, 03406-05501 or 03406-66508, it must be replaced by the same part number. The new rear panel, 03406-00224, will accept either line filter.

5-56. In addition to the DC voltage levels given on the power supply schematic, power supply regulation and ripple checks are given below.

5-57. POWER SUPPLY REGULATION CHECK.

a. A variable power-line transformer (Superior Type VC1M) and dc voltmeter (-hp- Model 414A) are required for this check.

b. On the Top Assembly (A2) connect dc voltmeter between + 15 volt test point and the ground test point.

c. With the variable power-line transformer vary the line voltage + and - 10% and verify that the dc voltmeter does not vary by more than 0.2 volts from the dc voltage at normal line.

5-58. POWER SUPPLY RIPPLE CHECK.

a. An oscilloscope (-hp- Model 140A/1402A) is required for this test.

b. On the top Assembly (A2) connect an oscilloscope between + 15 volt test point and the ground test point.

c. At normal-line voltage the pulses observed on oscilloscope should be less than 150 mV peak-to-peak.

5-59. TROUBLESHOOTING USING SAMPLE HOLD OUTPUT.

5-60. Because of the circuit location of SAMPLE HOLD OUTPUT Jack, it may be used to divide the instrument into two different sections and isolate the trouble to one of the two sections. Refer to Figure 6-1 for location of SAMPLE HOLD OUTPUT jack. The section prior to SAMPLE HOLD OUTPUT includes the Sample Hold Circuit, Signal Amplifier, Stabilizing Amplifier, Sampling Probe and Pulse Generator Circuits. The section after the SAMPLE HOLD OUTPUT includes the Detector Circuit, Non-linear Meter Circuit and the Meter Damping/Hold Circuit.

5-61. With a known one volt at 1 MHz into the 3406A as outlined in Paragraphs 5-30 and 5-31 the SAMPLE HOLD OUTPUT should be 0.316 ± 3%.

NOTE

With a 1 volt sine wave input the SAMPLE HOLD OUTPUT reading will read the same on a true rms voltmeter as it will on an average responding voltmeter. However, if a nonsinusoidal wave is measured the true rms voltmeter reading will differ from the average responding voltmeter.

5-62. TROUBLESHOOTING THE STABILIZING AMPLIFIER LOOP.

5-63. To verify proper operation of the Stabilizing Amplifier perform the following steps.

a. Insert the probe into 1 VOLT receptacle with the CAL pushbutton released (out).

b. Depress .3 volt RANGE pushbutton.

c. Connect oscilloscope to SAMPLE HOLD OUTPUT jack, and set vertical sensitivity to 0.2 V/cm.

d. The SAMPLE HOLD OUTPUT observed on oscilloscope should be a single trace free of any excessive 10 Hz component.

e. Turning the SAMPLE HOLD BIAS both clockwise and counterclockwise, pulses should appear but decline back to a single trace.

NOTE

If the proper results are not received in step e check the continuity of orange wire between Probe Filter FL2 and Interconnecting Assembly before troubleshooting the Stabilizing Amplifier.

5-64. FACTORY SELECTED COMPONENTS.

5-65. The value of A2R28* is factory selected to match the gain of A2Q7 to the Sampling Probe Assembly. Following is the procedure for selecting value of A2R28*: (1.5 K to 3.3 K).

a. ZERO the Model 3406A according to Paragraph 3-8.

b. Insert bare probe into 1 VOLT receptacle; depress 1 volt RANGE and CAL pushbuttons.

c. Adjust front panel CALIBRATE control from full CW to full CCW and note meter indication at both ends. Range of CALIBRATE control should be from .8 to 1.2 V.

d. Decrease value of A2R28 to obtain .8 reading; increase value of A2R28 to obtain 1.2 reading.

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 3406A
Broadband Sampling Voltmeter
Serial No. ______________________

Tests Performed By ______________________
Date ______________________

DESCRIPTION	CHECK	
	Indication	Specification
Range-to-Range Tracking and 10 kHz to 10 MHz Accuracy.		
10 kHz	0.77 to 1.03 volts	________
20 kHz	0.82 to 0.98 volts	________
25 kHz	0.85 to 0.95 volts	________
100 kHz	0.87 to 0.93 volts	________
1 MHz	0.87 to 0.93 volts	________
10 MHz	0.87 to 0.93 volts	________
3 V range (+ 20 dB setting)	2.76 to 2.94 (3 scale)	________
3 V range (+ 10 dB setting)	0.81 to 0.99 (3 scale)	________
1 V range (+ 10 dB setting)	2.76 to 2.94 (3 scale)	________
1 V range (0 dB setting)	0.81 to 0.99 (3 scale)	________
.3 V range (0 dB setting)	2.76 to 2.94 (3 scale)	________
.3 V range (- 10 dB setting)	0.81 to 0.99 (3 scale)	________
.1 V range (- 10 dB setting)	2.76 to 2.94 (3 scale)	________
.1 V range (- 20 dB setting)	0.81 to 0.99 (3 scale)	________
.03 V range (- 20 dB setting)	2.76 to 2.94 (3 scale)	________
.03 V range (- 30 dB setting)	0.81 to 0.99 (3 scale)	________
.01 V range (- 30 dB setting)	2.76 to 2.94 (3 scale)	________
.01 V range (- 40 dB setting)	0.81 to 0.99 (3 scale)	________
.003 V range (- 40 dB setting)	2.76 to 2.94 (3 scale)	________
.003 V range (- 50 dB setting)	0.81 to 0.99 (3 scale)	________
.001 V range (- 50 dB setting)	2.76 to 2.94 (3 scale)	________
.001 V range (- 60 dB setting)	0.81 to 0.99 (3 scale)	________
10 MHz to 100 MHz Accuracy Check		
10 MHz	0.87 to 0.93 volts	________
100 MHz	0.87 to 0.93 volts	________
700 MHz to 1.2 GHz Accuracy Check		
700 MHz	0.0627 to 0.0787 volts	________
1 GHz	0.0627 to 0.0987 volts	________
1.2 GHz	0.0577 to 0.0837 volts	________
Input Impedance Check	greater than 200 kHz	________
Meter Response Time Check	less than 3 seconds	________
Sample Hold Output Noise Check	less than 55 mV	________

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number of each part, together with any applicable notes, and provides the following:

a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.

b. Description of the part. (See list of abbreviations below.)

c. Typical manufacturer of the part in a five-digit code. (See Appendix A for list of manufacturers.)

d. Manufacturer's part number.

6-3. Figure 6-1 illustrates the attaching hardware for Model 3406A; Figure 6-2 illustrates the -hp- Modular Cabinet, and Figure 6-3 illustrates the replaceable mechanical parts used in Model 3406A. Miscellaneous and mechanical parts not listed in one of the three figures are listed at the end of Table 6-1 under "Miscellaneous". Figure 6-4 identifies all the Model 3406A accessories in both probe kits and gives the model number or part number for each item.

6-4. ORDERING INFORMATION.

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. (See Appendix B for list of office locations.) Identify parts by their Hewlett-Packard part numbers.

6-6. NON-LISTED PARTS.

6-7. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

ABBREVIATIONS

Ag ... silver
Al ... aluminum
A ... ampere(s)
Au ... gold

C ... capacitor
cer ... ceramic
coef ... coefficient
com ... common
comp ... composition
conn ... connection

dep ... deposited
DPDT ... double-pole double-throw
DPST ... double-pole single-throw

elect ... electrolytic
encap ... encapsulated

F ... farad(s)
FET ... field effect transistor
fxd ... fixed

GaAs ... gallium arsenide
GHz ... gigahertz = 10^{+9} hertz
gd ... guard(ed)
Ge ... germanium
gnd ... ground(ed)

H ... henry(ies)
Hg ... mercury

Hz ... hertz (cycle(s) per second)

ID ... inside diameter
impg ... impregnated
incd ... incandescent
ins ... insulation(ed)

kΩ ... kilohm(s) = 10^{+3} ohms
kHz ... kilohertz = 10^{+3} hertz

L ... inductor
lin ... linear taper
log ... logarithmic taper

mA ... milliampere(s) = 10^{-3} amperes
MHz ... megahertz = 10^{+6} hertz
MΩ ... megohm(s) - 10^{+6} ohms
met flm ... metal film
mfr ... manufacturer
ms ... millisecond
mtg ... mounting
mV ... millivolt(s) = 10^{-3} volts
μF ... microfarad(s)
μs ... microsecond(s)
μV ... microvolt(s) = 10^{-6} volts
my ... Mylar®

nA ... nanoampere(s) = 10^{-9} amperes
NC ... normally closed
Ne ... neon
NO ... normally open

NPO ... negative positive zero (zero temperature coefficient)
ns ... nanosecond(s) = 10^{-9} seconds
nsr ... not separately replaceable

Ω ... ohm(s)
obd ... order by description
OD ... outside diameter

p ... peak
pA ... picoampere(s)
pc ... printed circuit
pF ... picofarad(s) 10^{-12} farads
piv ... peak inverse voltage
p/o ... part of
pos ... position(s)
poly ... polystyrene
pot ... potentiometer
p-p ... peak-to-peak
ppm ... parts per million
prec ... precision (temperature coeffient, long term stability and/or tolerance)

R ... resistor
Rh ... rhodium
rms ... root-mean-square
rot ... rotary

Se ... selenium
sect ... section(s)
Si ... silicon

sl ... slide
SPDT ... single-pole double-throw
SPST ... single-pole single-throw

Ta ... tantalum
TC ... temperature coefficient
TiO_2 ... titanium dioxide
tog ... toggle
tol ... tolerance
trim ... trimmer
TSTR ... transistor

V ... volt(s)
vacw ... alternating current working voltage
var ... variable
vdcw ... direct current working voltage

W ... watt(s)
w/ ... with
wiv ... working inverse voltage
w/o ... without
ww ... wirewound

* ... optimum value selected at factory, average value shown (part may be omitted)
** ... no standard type number assigned selected or special type

® Dupont de Nemours

DECIMAL MULTIPLIERS

Prefix	Symbols	Multiplier	Prefix	Symbols	Multiplier
tera	T	10^{12}	centi	c	10^{-2}
giga	G	10^{9}	milli	m	10^{-3}
mega	M or Meg	10^{6}	micro	μ	10^{-6}
kilo	K or k	10^{3}	nano	n	10^{-9}
hecto	h	10^{2}	pico	p	10^{-12}
deka	da	10	femto	f	10^{-15}
deci	d	10^{-1}	atto	a	10^{-18}

STD-B-2734

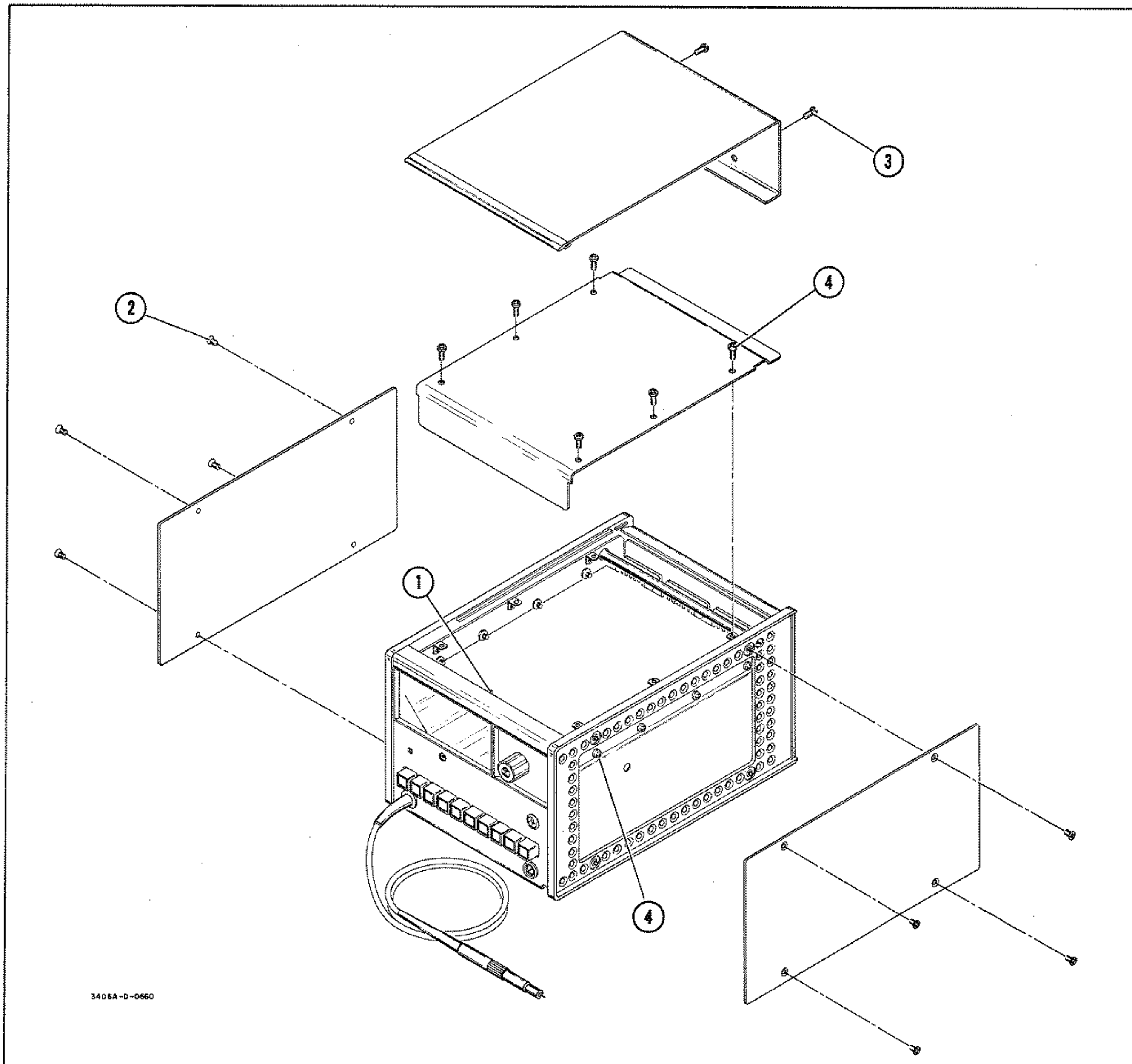
DESIGNATORS

A ... assembly
B ... motor
BT ... battery
C ... capacitor
CR ... diode
DL ... delay line
DS ... lamp
E ... misc electronic part
F ... fuse

FL ... filter
HR ... heater
IC ... integrated circuit
J ... jack
K ... relay
L ... inductor
M ... meter
MP ... mechanical part
P ... plug

Q ... transistor
QCR ... transistor-diode
R ... resistor
RT ... thermistor
S ... switch
T ... transformer
TB ... terminal board
TC ... thermocouple
TP ... test point

TS ... terminal strip
U ... microcircuit
V ... vacuum tube, neon bulb,photocell, etc.
W ... cable
X ... socket
XDS ... lampholder
XF ... fuseholder
Y ... crystal
Z ... network



INDEX NO.	DESCRIPTION	QTY.	-hp- PART NO.
1	Screw Mach 6-32 x 9/16 SS, with washer lock -hp- Part No. 2190-0008	1	2460-0028
2	Screw Mach SS 6-32 x 3/16	8	2370-0020
3	Screw Mach SS 6-32 x 1/4	2	2460-0010
4	Screw Mach SS 6-32 x 1/4 with washer-lock -hp- Part No. 2190-0008	14	2460-0010

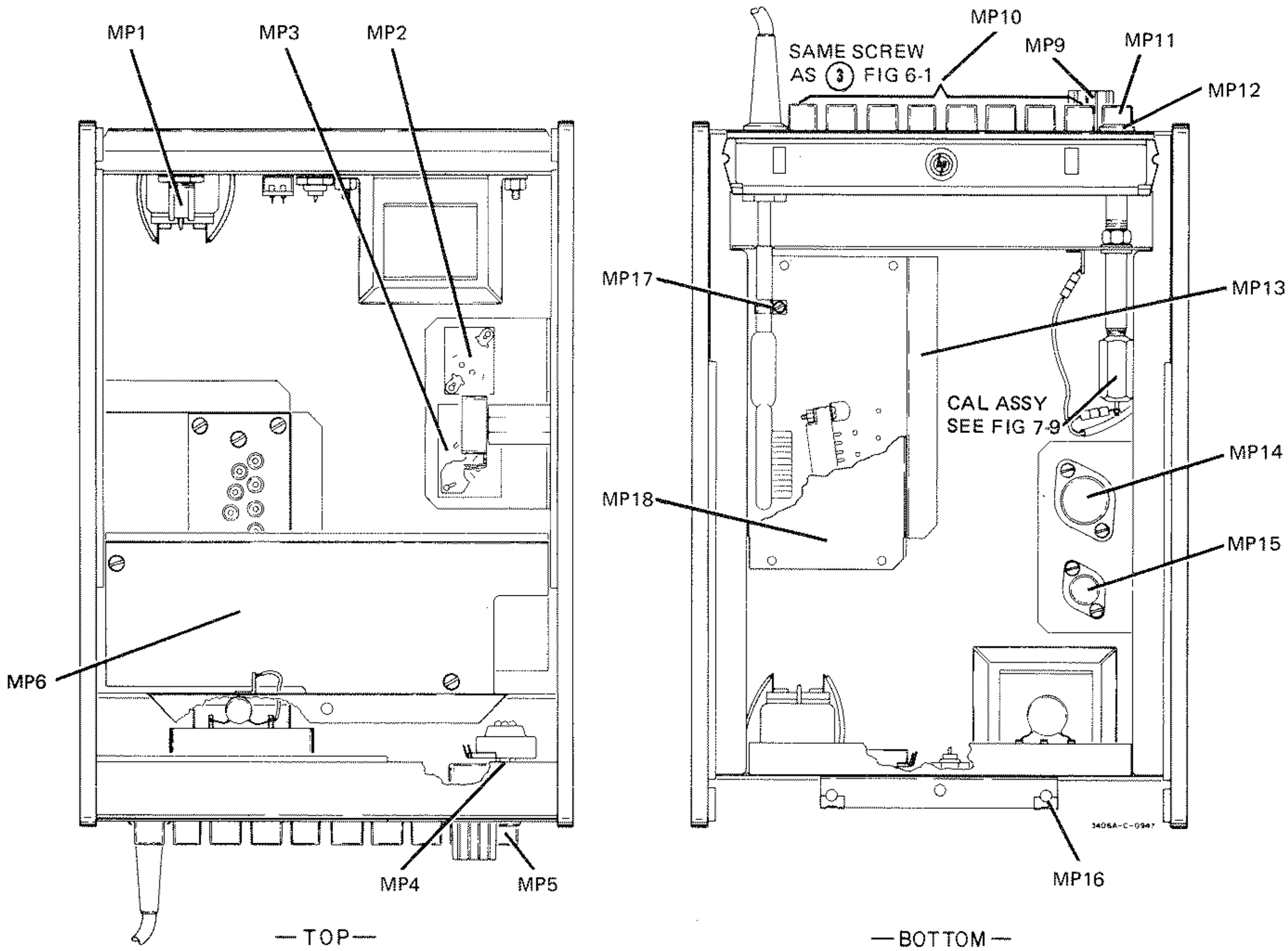
NOTE

The bottom cover is attached with two screws, Mach FH SS 6-32 x 5/16, -hp- Part No. 2370-0016. The bottom shield is attached with 13 screws the same type as No. (4) above.

CAUTION

THE TOP COVER SCREWS MUST NOT EXCEED 1/4 in. IN LENGTH; OTHERWISE, INTERNAL CIRCUITS MAY BE SHORTED.

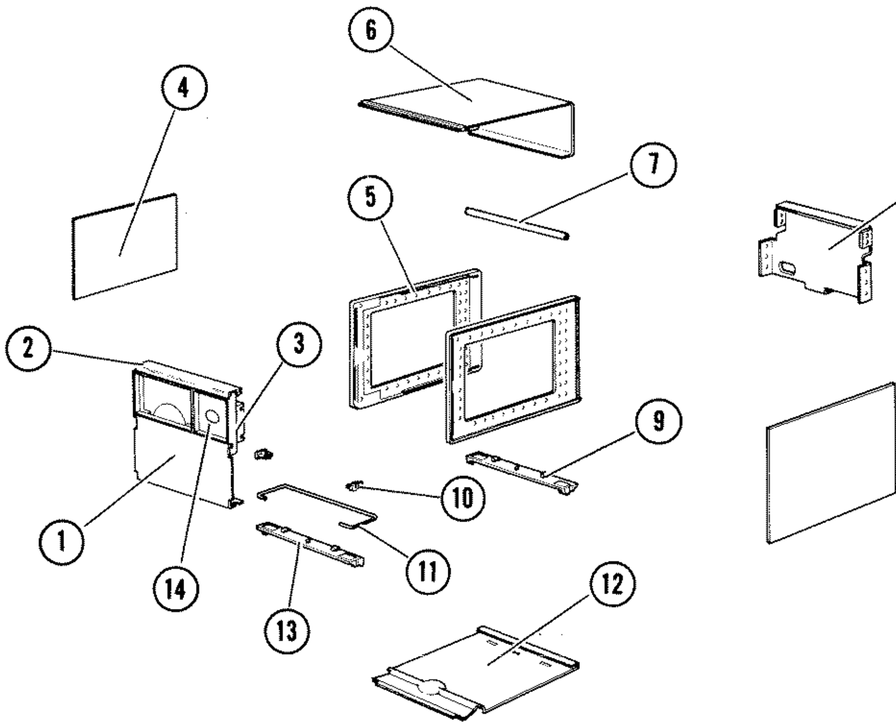
Figure 6-1. Attaching Hardware



REFERENCE DESIGNATOR	DESCRIPTION	QUANTITY	-hp- PART NO.
MP1	Fuseholder	1	1400-0084
MP2	Socket: TSTR (for Q1)	1	1200-0168
MP3	Socket: TSTR (for Q2)	1	1200-0041
MP4	Bushing: adapter (for CALIBRATE adj)	1	2950-0034
MP5	Bushing: Panel	1	1410-0052
MP6	Shield: range switch	1	03406-00603
MP8	Nut: boot, probe with washer-lock -hp- Part No. 2190-0037	1	03406-22111
MP9	Knob: (ZERO) Δ_1	1	0370-0025
MP10	Knob: Pushbutton (RANGE) Δ_1	9	0370-1392
MP11	Knob: Pushbutton (LINE) Δ_1	1	0370-2395
MP12	Bushing: calibrator (1 volt)	1	03406-41703
MP13	Bracket: filter, probe	1	03406-01203
MP14	Insulator: TSTR (for Q2)	1	1200-0077
MP15	Insulator: TSTR (for Q1)	1	0340-0140
MP16	Nut: sheet metal V type 6-32 (tinnerment)	2	0510-0075
MP17	Bracket: line filter	1	03406-01202
MP18	Clamp: probe cable	1	1400-0014
MP19	Shield: filter, probe	1	03406-00604

Δ_1 Refer to Section VIII.

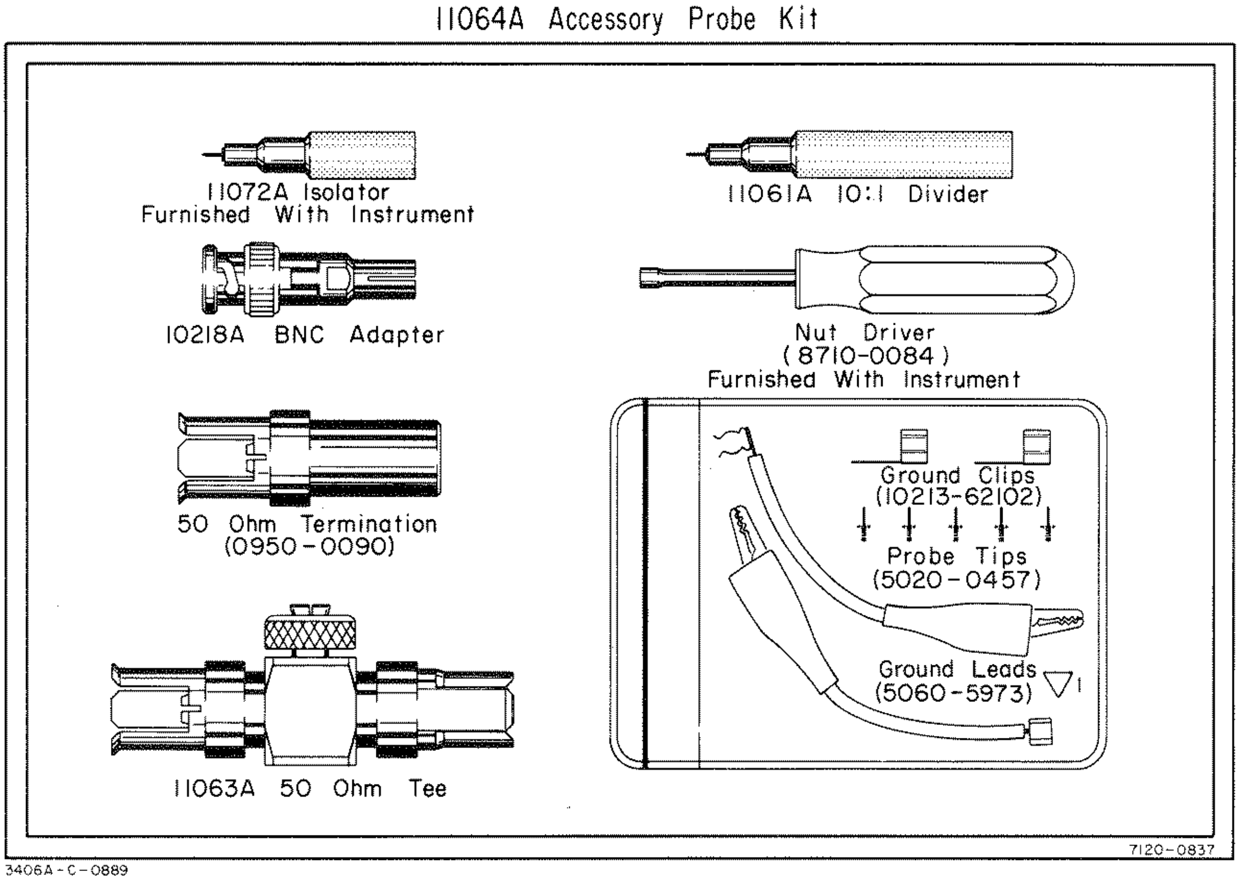
Figure 6-2. Mechanical Parts

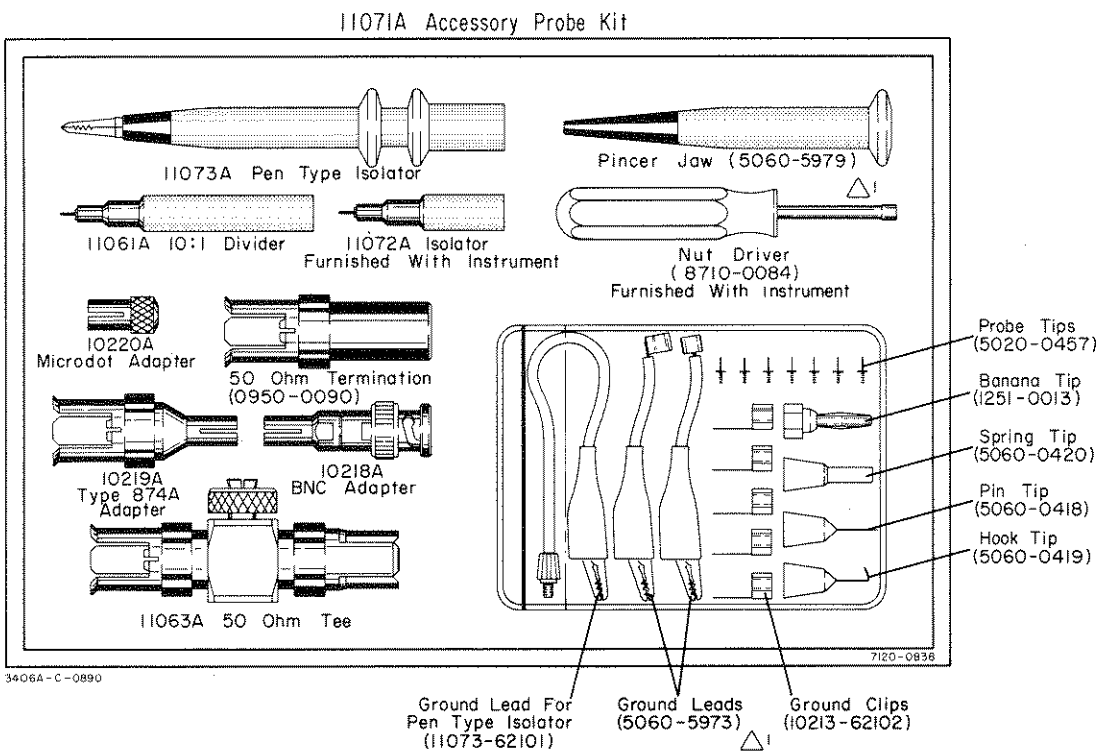


INDEX NO.	DESCRIPTION	QUANTITY	-hp- PART NO.
1	Δ_1 Panel: front	1	03406-00207
2	Meter trim: half module	1	5020-6853
3	Extender: meter case	1	5040-0701
4	Side Cover: 6 x 11 SM	2	5000-8565
5	Frame assembly: 6 x 11 SM	2	5060-0703
6	Top cover assembly: 7 x 11 SM	6	5060-8573
7	Cabinet spacer: half module	1	5020-0701
8	Panel: rear	1	03406-00224
9	Foot assembly: rear 7 x 11 SM	1	241A-44A
10	Hinge	2	5040-0700
11	Stand: tilt	1	1490-0032
12	Bottom cover: 7 x 11 SM	1	5000-8583
13	Foot assembly: front 7 x 11 SM	1	5060-0728
14	Panel: Insert (ZERO)	1	03406-04302

Δ_1 Refer to Section VIII.

Figure 6-3. Modular Cabinet





Δ_1 Refer to Section VIII.

Figure 6-4. Replacement Part No's and Model No's for Accessories

Table 6-1. Replaceable Parts

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A1 (NEW)	**03406-62104**		**Assembly: Sampling Probe**	-hp-	**PC 9-7207**
	03406-22115		**Housing: Probe Tip**	-hp-	
A1 (EXCHANGE)	**03406-62106** Δ_1		**Assembly: Sampling Probe**	-hp-	**PC 9-7733**
			NOTE This complete Sampling Probe Assembly (A1) is available only on an exchange basis. Refer to Section V for procedures outlining the removal and installation of the Sampling Probe Assembly.		
	03406-62105		**Housing: Probe**	-hp-	
A2	**03406-66501**		**Assembly: Board, top**	-hp-	
C1	0180-0100	2	C: fxd Ta 4.7 uF 10% 35 vdcw	56289	150D475X9035B2
C2	0180-0155	5	C: fxd Ta 2.2 uF 20% 20 vdcw	56289	150D225X0020A2
C3	0150-0014	3	C: fxd cer 0.005 uF 500 vdcw	04222	D1-4
C4	0180-0228	2	C: fxd Ta elect 22 uF 10% 15 vdcw	56289	150D226X9015B2
C5	0150-0084	7	C: fxd cer 0.1 uF +80% -20% 500 vdcw	56289	33C41
C6	0140-0152	3	C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J
C7	0180-0106	1	C: fxd Ta 60 uF 20% 6 vdcw	56289	150D606X0006B2
C8	0180-0058	8	C: fxd Al elect 50 uF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
C9	0150-0084		C: fxd cer 0.1 uF +80% -20% 500 vdcw	56289	33C41
C10,C11	0150-0096	3	C: fxd cer 0.05 uF +80% -20% 100 vdcw	72982	845-X5V-503Z
C12	0140-0152		C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J
C13	0140-0177	1	C: fxd mica 400 pF 1% 300 vdcw	04062	RDM15F401F3C
C14	0140-0208	2	C: fxd mica 680 pF 5% 300 vdcw	04062	RDM15F681J3C
C15	0160-0127	1	C: fxd cer 1 uF 20% 25 vdcw	56289	5C13
C16	0180-0058		C: fxd Al elect 50 uF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
C17	0180-0224	1	C: fxd Al elect 10 uF +75% -10% 15 vdcw	56289	30D106G015BA4
C18	0180-0228		C: fxd Ta elect 22 uF 10% 15 vdcw	56289	150D226X9015B2
C19	0160-0168	2	C: fxd my 0.1 uF 10% 200 vdcw	56289	192P10492
C20	0150-0084		C: fxd cer 0.1 uF +80% -20% 500 vdcw	56289	33C41
C21	0180-0058		C: fxd Al elect 50 uF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
C22,C23			Not assigned		
C24	0180-0155		C: fxd Ta 2.2 uF 20% 20 vdcw	56289	150D225X0020A2
C25	0180-0058		C: fxd Al elect 50 uF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
C26	0180-0155		C: fxd Ta 2.2 uF 20% 20 vdcw	56289	150D225X0020A2
C27			Not assigned		
C28	0180-0155		C: fxd Ta 2.2 uF 20% 20 vdcw	56289	150D225X0020A2
C29	0180-0100		C: fxd Ta 4.7 uF 10% 35 vdcw	56289	150D475X9035B2
C30	0160-0168		C: fxd my 0.1 uF 10% 200 vdcw	56289	192P10492
C31	0160-0174	1	C: fxd cer 0.47 uF +80% -20% 25 vdcw	56289	5C11B7
C32	0160-2018	1	C: fxd mica 250 pF 5% 500 vdcw	04062	RDM15F251J5S
CR1,CR2	1902-0049	4	Diode: breakdown 6.19 V 5% 400 mW	07263	obd
CR3	1901-0040	34	Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR4,CR5	1901-0033	2	Diode: Si**	28480	1901-0033
CR6 thru CR12	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR13			Not assigned		
CR14	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR15			Not assigned		
CR16 thru CR22	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
L1	9170-0016	4	Ferrite Bead (for Q2)	-hp-	

Δ_1 Refer to Section VIII.

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2 (Cont'd)					
Q1	1854-0071	22	TSTR: Si NPN 2N3391	24446	2N3391
Q2	1854-0087	3	TSTR: Si NPN**	-hp-	
Q3 thru Q6	1854-0071	1	TSTR: Si NPN 2N3391	24446	2N3391
Q7	1855-0073	2	TSTR: Si P-Channel FET	-hp-	
Q8	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
Q9	1854-0094	2	TSTR: Si NPN 2N3646	07263	2N3646
Q10 thru Q12	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
Q13	1853-0016	8	TSTR: Si PNP 2N3638	07263	2N3638
Q14,Q15	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
Q16	1854-0087	2	TSTR: Si NPN 2N3417	24446	2N3417
Q17,Q18	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
Q19,Q20	1853-0016		TSTR: Si PNP 2N3638	07263	2N3638
Q21	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
R1	0687-1031	9	R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R2	0687-2721	4	R: fxd comp 2700 ohms 10% 1/2 W	01121	EB 2721
R3,R4	0687-1821	3	R: fxd comp 1800 ohms 10% 1/2 W	01121	EB 1821
R5	0687-8231	3	R: fxd comp 82 kilohms 10% 1/2 W	01121	EB 8231
R6	0687-2241	2	R: fxd comp 220 kilohms 10% 1/2 W	01121	EB 2241
R7	0687-1011	5	R: fxd comp 100 ohms 10% 1/2 W	01121	EB 1011
R8	0687-1041	1	R: fxd comp 100 kilohms 10% 1/2 W	01121	EB 1041
R9	0687-2241		R: fxd comp 220 kilohms 10% 1/2 W	01121	EB 2241
R10	0687-3331	3	R: fxd comp 33 kilohms 10% 1/2 W	01121	EB 3331
R11	0687-1831	1	R: fxd comp 18 kilohms 10% 1/2 W	01121	EB 1831
R12	0698-3138	2	R: fxd prec met flm 277.5 ohms 1/4% 1/4 W	91637	MFF-1/4 T-O obd
R13	0687-6821	7	R: fxd comp 6800 ohms 10% 1/2 W	01121	EB 6821
R14	0687-3331		R: fxd comp 33 kilohms 10% 1/2 W	01121	EB 3331
R15	0687-1821		R: fxd comp 1800 ohms 10% 1/2 W	01121	EB 1821
R16			Not assigned		
R17	0687-5631	2	R: fxd comp 56 kilohms 10% 1/2 W	01121	EB 5631
R18	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R19	2100-0095	2	R: var lin 100 kilohms 30%	-hp-	
R20	0687-4701	2	R: fxd comp 47 ohms 10% 1/2 W	01121	EB 4701
R21 thru R23			Not assigned		
R24,R25	0687-5601	3	R: fxd comp 56 ohms 10% 1/2 W	01121	EB 5601
R26	0687-4711	1	R: fxd comp 470 ohms 10% 1/2 W	01121	EB 4711
R27	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R28* Δ_1	0687-2221	1	R: fxd comp 2200 ohms 10% 1/2W	01121	EB 2221
R29,R30	0687-2721		R: fxd comp 2700 ohms 10% 1/2 W	01121	EB 2721
R31	0687-2221	6	R: fxd comp 2200 ohms 10% 1/2 W	01121	EB 2221
R32	0687-1021	7	R: fxd comp 1000 ohms 10% 1/2 W	01121	EB 1021
R33	0687-4701		R: fxd comp 47 ohms 10% 1/2 W	01121	EB 4701
R34	0687-3931	1	R: fxd comp 39 kilohms 10% 1/2 W	01121	EB 2231
R35	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R36	0687-2201	3	R: fxd comp 22 ohms 10% 1/2 W	01121	EB 2201
R37	0687-8231	10	R: fxd comp 82 kilohms 10% 1/2 W	01121	EB 8231
R38	0687-1531	9	R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R39	2100-0151	1	R: var lin 500 ohms 20%	-hp-	
R40	0687-1531		R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R41, R42, A17	0687-3311		R: fxd comp 330 ohms 10% 1/2W	01121	EB 1011
R43	0687-2711	4	R: fxd comp 270 ohms 10% 1/2W	01121	EB 2711
R44	0687-2221		R: fxd comp 2200 ohms 10% 1/2 W	01121	EB 2221
R45	0687-1531		R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R46	0687-2201		R: fxd comp 22 ohms 10% 1/2 W	01121	EB 2201
R47	0687-1541	1	R: fxd comp 150 kilohms 10% 1/2 W	01121	EB 1541
R48	0687-8221	5	R: fxd comp 8200 ohms 10% 1/2 W	01121	EB 8221
R49	0687-2211	4	R: fxd comp 220 ohms 10% 1/2 W	01121	EB 2211
R50	0687-8221		R: fxd comp 8200 ohms 10% 1/2 W	01121	EB 8221
R51	0687-2731	1	R: fxd comp 27 kilohms 10% 1/2 W	01121	EB 2731

Δ_1, A17 Refer to Section VIII.

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2 (Cont'd)					
R52	0686-1645	1	R: fxd comp 160 kilohms 5% 1/2 W	01121	EB 1645
R53	0686-3035	1	R: fxd comp 30 kilohms 5% 1/2 W	01121	EB 3035
R54	0687-2211		R: fxd comp 220 ohms 10% 1/2 W	01121	EB 2211
R55,R56	0687-2221		R: fxd comp 2200 ohms 10% 1/2 W	01121	EB 2221
R57	0757-0730	2	R: fxd prec met flm 750 ohms 1% 1/4 W	19701	MF6C T-O obd
R58	0687-1521	4	R: fxd comp 1500 ohms 10% 1/2 W	01121	EB 1521
R59	0687-4721	7	R: fxd comp 4700 ohms 10% 1/2 W	01121	EB 4721
R60	0757-0764		R: fxd prec met flm 33.2 kilohms 1% 1/4 W	19701	MF6C T-O obd
R61	0757-0747	2	R: fxd prec met flm 5110 ohms 1% 1/4 W	19701	MF6C T-O obd
R62	0757-0764	2	R: fxd prec met flm 33.2 kilohms 1% 1/4 W	19701	MF6C T-O obd
R63	0757-0121	1	R: fxd prec met flm 258 kilohms 1% 1/4 W	19701	MF6C T-O obd
R64	0687-6831	3	R: fxd comp 68 kilohms 10% 1/2 W	01121	EB 6831
R65,R66	0687-1531		R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R67			Not assigned		
R68	0687-1531		R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R69,R70	0687-4721		R: fxd comp 4700 ohms 10% 1/2 W	01121	EB 4721
R71	0698-3212	1	R: fxd prec met flm 249 kilohms 1% 1/4 W	19701	MF6C T-O obd
R72	0687-3331		R: fxd comp 33 kilohms 10% 1/2 W	01121	EB 3331
R73	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R74	0687-5601		R: fxd comp 56 ohms 10% 1/2 W	01121	EB 5601
R75	0757-0753	1	R: fxd prec met flm 9090 ohms 1% 1/4 W	19701	MF6C T-O obd
R76	0757-0746	2	R: fxd prec met flm 4750 ohms 1% 1/4 W	19701	MF6C T-O obd
R77	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R78	0757-0730		R: fxd prec met flm 750 ohms 1% 1/4 W	19701	MF6C T-O obd
R79	0757-0765	1	R: fxd prec 36.5 K 1% 1/4 W	19701	MF6C T-O obd
R80	0757-0340	8	R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R81	2100-0154	3	R: var lin 1000 ohms 30%	-hp-	
R82	0698-3144	1	R: fxd prec met flm 8870 ohms 1% 1/4 W	19701	MF6C T-O obd
R83	0757-0340		R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R84	2100-0154		R: var lin 1000 ohms 30%	-hp-	
R85	0698-3283	2	R: fxd prec met flm 9310 ohms 1% 1/4 W	19701	MF6C T-O obd
R86	0757-0340		R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R87	2100-0154		R: var lin 1000 ohms 30%	-hp-	
R88	0698-3283		R: fxd prec met flm 9310 ohms 1% 1/4 W	19701	MF6C T-O obd
R89	0757-0340		R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R90	2100-0090	1	R: var lin 2000 ohms 30%	-hp-	
R91	0757-0340		R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R92	2100-0095	1	R: var lin 100 kilohms 30%	-hp-	
R93			Not assigned		
R94	2100-0092	3	R: var lin 10 kilohms 20%	-hp-	
R95	2100-0094	2	R: var lin 50 kilohms 30%	-hp-	
R96			Not assigned		
R97,R98	2100-0092		R: var lin 10 kilohms 20%	-hp-	
R99	2100-0093	1	R: var lin 20 kilohms 20%	-hp-	
R100	2100-0091	1	R: var lin 5000 ohms 30%	-hp-	
R101	2100-0094		R: var lin 50 kilohms 30%	-hp-	
R102	2100-0182	1	R: var lin 3300 ohms 10%	-hp-	
R103	0687-6821		R: fxd comp 6800 ohms 10% 1/2 W	01121	EB 6821
R104			Not assigned		
R105	0687-2221		R: fxd comp 2200 ohms 10% 1/2 W	01121	EB 2221
R106	0687-8221		R: fxd comp 8200 ohms 10% 1/2 W	01121	EB 2221
R107			Not assigned		
R108	0687-3321	2	R: fxd comp 3300 ohms 10% 1/2 W	01121	EB 3321
R109	0687-2721		R: fxd comp 2700 ohms 10% 1/2 W	01121	EB 2721
R110	0687-6821		R: fxd comp 6800 ohms 10% 1/2 W	01121	EB 6821
R111	0687-2221		R: fxd comp 2200 ohms 10% 1/2 W	01121	EB 2221
R112	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R113	0687-2221		R: fxd comp 2200 ohms 10% 1/2 W	01121	EB 2221
R114	0757-0746		R: fxd prec met flm 4750 ohms 1% 1/4 W	19701	MF6C T-O obd
R115	0757-0734	1	R: fxd prec met flm 1210 ohms 1% 1/4 W	91637	MFF-1/4 T-O obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A2 (Cont'd)					
R116			Not assigned		
R117	0757-0728	1	R: fxd prec met flm 619 ohms 1% 1/4 W	19701	MF6C T-O obd
R118	0687-1521		R: fxd comp 1500 ohms 10% 1/2 W	01121	EB 1521
A3	**03406-66502**		**Assembly: Board, bottom**	**-hp-**	
C1	0150-0084		C: fxd cer 0.1 uF +80% -20% 500 vdcw	56289	33C41
C2	0140-0152	2	C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J
C3,C4	0160-2348	1	C: set matched my 4 uF 20% 30 vdcw	56289	Type 148P obd
C5	0150-0084		C: fxd cer 0.1 uF +80% -20% 500 vdcw	56289	33C41
C6	0180-0155		C: fxd Ta 2.2 uF 20% 20 vdcw	56289	150D225X0020A2
C7	0140-0152		C: fxd mica 1000 pF 5% 300 vdcw	04062	DM16F102J
C8	0140-0208		C: fxd mica 680 pF 5% 300 vdcw	04062	RDM15F681J3C
C9	0140-0234	1	C: fxd mica 500 pF 1% 300 vdcw	04062	RDM15F501F3C
C10	0150-0096		C: fxd cer 0.05 uF +80% -20% 100 vdcw	72982	845-X5V-503Z
C11	0150-0014		C: fxd cer 0.005 uF 500 vdcw	04222	D1-4
C12	0180-0097	1	C: fxd Al elect 47 uF 10% 35 vdcw	56289	150D476X9035S2-DVS
C13	0150-0014		C: fxd cer 0.005 uF 500 vdcw	04222	D1-4
C14	0160-0195	1	C: fxd cer 0.001 uF 20% 250 vacw	56289	19C251A
C15	0180-0353	2	C: fxd Al elect 450 uF +100% -10% 50 vdcw	56289	D38702
C16	0150-0084		C: fxd cer 0.1 uF +80% -20% 500 vdcw	56289	33C41
C17,C18	0180-0058		C: fxd Al elect 50 uF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
C19	0180-0353		C: fxd Al elect 450 uF +100% -10% 50 vdcw	56289	D38702
C20,C21	0150-0084		C: fxd cer 0.1 uF +80% -20% 500 vdcw	56289	33C41
C22,C23	0180-0058		C: fxd Al elect 50 uF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
C24,C25	0180-0039	2	C: fxd Al elect 100 uF +75% -10% 12 vdcw	56289	30D107G012CC2-DSM
C26	0160-0170	1	C: fxd cer 0.22 uF +80% -20% 25 vdcw	56289	30D107G012CC2-DSM
CR1 thru CR6	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR7			Not assigned		
CR8	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR9	1902-1169	1	Diode: Si breakdown 7.5 V 5% 250 mW	04713	obd
CR10	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR11	1901-0050	1	Diode: Si 200 mA at +1 V 75 V 2 pF 2 ns	07263	FD6195
CR12	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR13,CR14	1901-0039	2	Diode: Switching Si 50 piv 200 mA at +1 V 6 pF 8 ns	03877	
CR15 thru CR18	1901-0158	4	Diode: Rectifier Si 200 piv	04713	SR1358-3
CR19 thru CR22	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR23	1902-0049		Diode: breakdown 6.19 V 5% 400 mW	07263	obd
CR24	1902-0761	1	Diode: breakdown 6.2 V 0.01% IN821	04713	IN821
CR25 thru CR28	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR29	1902-0049		Diode: breakdown 6.19 V 5% 400 mW	07263	obd
CR30,CR31	1901-0040		Diode: Si 30 mA at +1 V 30 piv 2 pF 2 ns	03877	SG5050
CR32	1902-3190	1	Diode: breakdown 13.0 V	04713	SZ10939-215
K1	0490-0180	1	Relay: form C 12 Vdc	80089	61-146
Q1	1854-0005	2	TSTR: Si NPN 2N708	02735	obd
Q2	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
Q3	1855-0073		TSTR: Si P-Channel FET	-hp-	
Q4	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
Q5	1853-0016		TSTR: Si PNP 2N3638	07263	2N3638

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A3 (Cont'd)					
Q6 thru Q8	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
Q9	1853-0016		TSTR: Si PNP 2N3638	07263	2N3638
Q10	1855-0010	1	TSTR: Si 2N2646 uni junction	03508	2N2646 obd
Q11	1854-0005	1	TSTR: Si NPN 2N708	01295	2N708
Q12	1854-0432		TSTR: Si NPN 2N3646	07263	2N3646 obd
Q13	1853-0016		TSTR: Si PNP 2N3638	07263	2N3638
Q14	1854-0087		TSTR: Si NPN 2N3417	24446	2N3417
Q15,Q16	1854-0071		TSTR: Si NPN 2N3391	24446	2N3391
Q17	1853-0020	1	TSTR: Si PNP	01295	SM-9143
Q18,Q19	1853-0016		TSTR: Si PNP 2N3638	07263	2N3638
Q20	1854-0003	1	TSTR: Si NPN 2N1711	81453	RT5299
R1	0757-0732	1	R: fxd prec met flm 909 ohms 1% 1/4 W	19701	MF6C T-O obd
R2	2100-2475	2	R: var lin 1000 ohms 30%	71450	XPE200RE obd
R3	0698-3208	1	R: fxd prec met flm 4990 ohms 1% 1/4 W	91637	MF-1/8-44 obd
R4	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R5,R6	0687-2211		R: fxd comp 220 ohms 10% 1/2 W	01121	EB2211
R7	0687-1531		R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R8	2100-2475		R: var lin 1000 ohms 30%	71450	XPE200RE obd
R9	0687-6821		R: fxd comp 6800 ohms 10% 1/2 W	01121	EB 6821
R10	0687-2711		R: fxd comp 270 ohms 10% 1/2 W	01121	EB 2711
R11	0757-0344	2	R: fxd prec met flm 1 megohm 1% 1/4 W	19701	MF6C T-O obd
R12	0757-0340		R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R13	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R14	0687-6801	1	R: fxd comp 68 ohms 10% 1/2 W	01121	EB 6801
R15	0687-5621	1	R: fxd comp 5600 ohms 10% 1/2 W	01121	EB 5621
R16	2100-2548	1	R: var lin 3300 ohms 10%	71450	XPE200RE obd
R17			Not assigned		
R18	0687-4731	1	R: fxd comp 47 kilohms 10% 1/2 W	01121	EB 4731
R19	0687-6821		R: fxd comp 6800 ohms 10% 1/2 W	01121	EB 6821
R20	0687-1821		R: fxd comp 1800 ohms 10% 1/2 W	01121	EB 1821
R21	0757-0344		R: fxd prec met flm 1 megohm 1% 1/4 W	19701	MF6C T-O obd
R22	0687-1031		R: fxd comp 10 kilohms 10% 1/2 W	01121	EB 1031
R23	0757-0340		R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R24	0687-5611	4	R: fxd comp 560 ohms 10% 1/2 W	01121	EB 5611
R25	0757-0340		R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R26	0757-0747		R: fxd prec met flm 5110 ohms 1% 1/4 W	19701	MF6C T-O obd
R27			Not assigned		
R28	0687-6811	2	R: fxd comp 680 ohms 10% 1/2 W	01121	EB 6811
R29	0687-8221		R: fxd comp 8200 ohms 10% 1/2 W	01121	EB 8221
R30	0687-6831		R: fxd comp 68 kilohms 10% 1/2 W	01121	EB 6831
R31	0687-8221		R: fxd comp 8200 ohms 10% 1/2 W	01121	EB 8221
R32	0687-6831		R: fxd comp 68 kilohms 10% 1/2 W	01121	EB 6831
R33	0687-1531		R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R34	0687-5631		R: fxd comp 56 kilohms 10% 1/2 W	01121	EB 5631
R35	0687-4721		R: fxd comp 4700 ohms 10% 1/2 W	01121	EB 4721
R36,R37	0686-1035	2	R: fxd comp 10 kilohms 5% 1/2 W	-hp-	
R38	0686-9125	1	R: fxd comp 9100 ohms 5% 1/2 W	01121	EB 9125
R39	0687-1021		R: fxd comp 1000 ohms 10% 1/2 W	01121	EB 1021
R40	0757-0340		R: fxd prec met flm 10 kilohms 1% 1/4 W	19701	MF6C T-O obd
R41	0687-3321		R: fxd comp 3300 ohms 10% 1/2 W	01121	EB 3321
R42	0687-5611		R: fxd comp 560 ohms 10% 1/2 W	01121	EB 5611
R43	0687-1011		R: fxd comp 100 ohms 10% 1/2 W	01121	EB 1011
R44	0687-1021		R: fxd comp 1000 ohms 10% 1/2 W	01121	EB 1021
R45	0687-4721		R: fxd comp 4700 ohms 10% 1/2 W	01121	EB 4721
R46	0687-1521		R: fxd comp 1500 ohms 10% 1/2 W	01121	EB 1521
R47 thru R49	0757-1000	3	R: fxd prec met flm 51.1 ohms 1% 1/2 W	91637	MFF 1/2 T-O obd

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
A3 (Cont'd)					
R50	0687-4721		R: fxd comp 4700 ohms 10% 1/2 W	01121	EB 4721
R51	0687-1021		R: fxd comp 1000 ohms 10% 1/2 W	01121	EB 1021
R52	0698-3559	2	R: fxd comp 3.9 ohms 10% 1/2 W	01121	EB 39G1
R53	0687-1521		R: fxd comp 1500 ohms 10% 1/2 W	01121	EB 1521
R54	0687-5611		R: fxd comp 560 ohms 10% 1/2 W	01121	EB 5611
R55	0687-1021		R: fxd comp 1000 ohms 10% 1/2 W	01121	EB 1021
R56	0687-1011		R: fxd comp 100 ohms 10% 1/2 W	01121	EB 1011
R57,R58	0698-4052	2	R: fxd prec met flm 6980 ohms 1% 1/4 W	19701	MF6C T-O obd
R59	0687-4721		R: fxd comp 4700 ohms 10% 1/2 W	01121	EB 4721
R60	0687-1221	1	R: fxd comp 1200 ohms 10% 1/2 W	01121	EB 1221
R61 Δ_3	0698-3559	1	R: fxd comp 3.9 ohms 10% 1/2 W	01121	EB39G1
R62	0687-6811		R: fxd comp 680 ohms 10% 1/2 W	01121	EB 6811
R63	0687-1021		R: fxd comp 1000 ohms 10% 1/2 W	01121	EB 1021
R64	0687-5611		R: fxd comp 560 ohms 10% 1/2 W	01121	EB 5611
R65	0687-1011		R: fxd comp 100 ohms 10% 1/2 W	01121	EB 1011
R66	0757-0339	1	R: fxd prec met flm 3010 ohms 1% 1/4 W	19701	MF6C T-O obd
R67	2100-2547	1	R: var lin 500 ohms 30%	71540	XPE200RE obd
R68	0757-0745	1	R: fxd prec met flm 4320 kilohms 1% 1/4 W	19701	MF6C T-O obd
R69	0687-3311	2	R: fxd comp 330 ohms 10% 1/2 W	01121	EB 3311
R70	2100-2454	1	R: var lin 100 kilohms 30%	71450	XPE200RE obd
R71	0687-1531		R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R72	2100-2456	1	R: var lin 10 kilohms 30% 1/8 W	71450	XPE200RE obd
R73	0687-1531		R: fxd comp 15 kilohms 10% 1/2 W	01121	EB 1531
R74,R75	0687-4721		R: fxd comp 4700 ohms 10% 1/2 W	01121	EB 4721
R76	0687-1021		R: fxd comp 1000 ohms 10% 1/2 W	01121	EB 1021
R77,R78	0687-6821		R: fxd comp 6800 ohms 10% 1/2 W	01121	EB 6821
T1	9100-1338	1	Transformer: pulse	-hp-	
T2	9100-1323	1	Transformer: pulse	-hp-	
FL1	**9100-3121**	**1**	**Transformer: filter**	**-hp-**	
C1, 2, Δ_{16}	0160-0195	2	C: fxd 1000 PF +−20% 250 vdcw	-hp-	
C3, C4 Δ_2	0160-3333	2	C: fxd cer 0.005 µF 250 vdcw	-hp-	
C5, C6 Δ_{16}	0160-0195	2	C: fxd 1000 PF +−20% 250 vdcw	72982	801-010X5G0102Z
L1,L2	9100-1331	2	Inductor: fxd 3 mH	-hp-	
L3 thru L5	9100-1491	3	Inductor	-hp-	
L6 thru L8	9170-0016	3	Bead: ferrite shielding	02114	56-590-65A1/3B

Δ_2, Δ_3 Refer to Section VIII.

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
FL1 (Cont'd)					
R1,R2	0684-1021	3	R: fxd comp 1000 ohms 10% 1/4 W	01121	CB 1021
R3,R4	0687-3311		R: fxd comp 330 ohms 10% 1/2 W	01121	EB 3311
FL2	**03406-62702**		**Assembly: Probe Filter**	**-hp-**	
C1,C2	0160-3496	2	C: fxd cer 100 pF 10% 500 vdcw	01121	FB2B-1011
C3 thru C7	0160-3495	5	C: fxd cer 470 pF 10% 50 vdcw	01121	FB2B-4711
FL3	**03406-63202**		**Assembly: Filter Calibrator**	**-hp-**	
C1,C2	0160-2360	2	C: fxd cer 100 pF 10% 300 vdcw	01121	FUGD
R1	0684-1021		R: fxd comp 1000 ohms 10% 1/4 W	01121	CB 1021
S1	**03406-61901**		**Assembly: Switch Range**	**-hp-**	
R1	0698-4162	1	R: fxd prec met flm 30.79 ohms 1/4% 1/4 W	91637	MFF-1/4 T-O obd
R2	0698-4163	1	R: fxd prec met flm 128.1 ohms 1/4% 1/4 W	91637	MFF-1/4 T-O obd
R3	0687-1511	1	R: fxd prec comp 150 ohms 10% 1/2 W	01121	EB 1511
R4 thru R8	0698-3139	5	R: fxd prec met flm 410.26 ohms 1/4% 1/4 W	91637	MFF-1/4 T-O obd
R9 thru R12	0698-3138		R: fxd prec met flm 277.5 1/4% 1/4 W	91637	MFF-1/4 T-O obd
R13	0698-4574	1	R: fxd prec met flm 210 ohms 1/4% 1/4 W	-hp-	
R14	0687-1831		R: fxd comp 18 kilohms 10% 1/2 W	01121	EB 1831
			CHASSIS MOUNTED COMPONENTS		
C1	0180-0058		C: fxd Al elect 50 uF +75% -10% 25 vdcw	56289	30D506G025CC2-DSM
C2	0150-0012	1	C: fxd cer 0.01 uF 20% 1000 vdcw	56289	29C214A3
C3	0150-0052	1	C: fxd cer 0.05 uF 20% 400 vdcw	56289	33C17A

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
			CHASSIS MOUNTED COMPONENTS		
F1	2110-0201	1	Fuse: 0.25 amps 250 V slow-blow	-hp-	
J1	5020-6828	1	Connector: power	-hp-	
J2, 3	1250-0083	2	Connector: BNC	95712	30624-1
J4 – 7	1251-0478	4	Connector: 12 pin	07233	64-718-6
J8, 9	1251-0472	2	Connector: 12 pin	07233	65-716
J10	1251-0198	1	Connector: 12 pin	-hp-	
M1	1120-0393	1	Meter	-hp-	
Q1	1854-0072	1	TSTR: Si NPN	86684	2N3054
Q2	1853-0052	1	TSTR: Si PNP	04713	2N3740
R1	2100-1801	1	R: var 25 kilohms 30% 1/3W	71450	5VA-45
R2	2100-0407	1	R: var 5000 ohms 10% (ZERO)	-hp-	
R4	2100-0136	1	R: var 6000 ohms 20% (RECORDER OUT)	71450	Type 70
R5	2100-0011	1	R: var 5000 ohms 20% (3 V F.S.)	-hp-	
S2	3101-1234	1	Switch: DPDT (115 - 230 V ac)	42190	4633
T1	9100-1322	1	Transformer: power	-hp-	
W1	1820-1348	1	Power Cable	-hp-	
			MISCELLANEOUS		
	03406-66503	1	Assembly: board interconnecting	-hp-	
	03406-63203	1	Assembly: calibrator (includes all parts for the 1 VOLT receptacle) See Figure 7-9.	-hp-	
	03406-62105	1	Assembly: housing probe	-hp-	
	9170-0016	20	Bead: ferrite	02114	56-590-65/3B
	03406-26505	1	Board: probe connector	-hp-	
	03406-01202	1	Bracket: line filter (FL1)	-hp-	
	2950-0034	1	Bushing: adapter (for CALIBRATE ADJ)	000LF	obd
	03406-41702	1	Bushing: calibrate (on front panel)	-hp-	
	1410-0052	1	Bushing: panel (for CALIBRATE ADJ)	95264	obd
	03406-05501	1	Can: line filter (FL1)	-hp-	
	03406-00101	1	Chassis: hinged	-hp-	
	10213-62102	2	Clip: ground	-hp-	
	5000-0717	1	Cover: bottom 7 X 11 submodule	-hp-	
	5000-0703	2	Cover: side 6 X 11 submodule	-hp-	
	5060-0718	1	Cover: top 7 X 11 submodule	-hp-	
	5040-0701	1	Extender: meter case	-hp-	
	241A-44A	1	Foot Assembly: 7 X 11 submodule	-hp-	
	5060-0728	1	Foot Assembly: 7 X 11 submodule	-hp-	
	5060-0703	2	Frame Assembly: 6 X 11 submodule	-hp-	
	1400-0084	1	Fuseholder	75915	342014
	03406-01101	1	Heat sink: TSTR (for Q1 and Q2)	-hp-	
	5040-0700	2	Hinge: (for tilt stand)	-hp-	
	0340-0060	3	Insulator: cloverleaf feed-thru teflon (used on A2 and A3 assemblies)	98291	FT-E-15
	03406-22112	1	Insulator: housing probe	-hp-	
	0340-0140	2	Insulator: transistor	02735	DF 31A
	0370-0132	10	Knob: pushbutton (RANGE)	-hp-	
	0370-0025	1	Knob: round black 3/4 in. dia. (ZERO)	-hp-	
	5001-0133	1	Label: pushbutton (LINE)	-hp-	
	5000-3220	1	Label: pushbutton .001 (-50)	-hp-	
	5000-3221	1	Label: pushbutton .003 (-40)	-hp-	
	5000-3222	1	Label: pushbutton .01 (-30)	-hp-	
	5000-3223	1	Label: pushbutton .03 (-20)	-hp-	

Table 6-1. Replaceable Parts (Cont'd)

REFERENCE DESIGNATOR	-hp- PART NO.	TQ	DESCRIPTION	MFR.	MFR. PART NO.
			MISCELLANEOUS (Cont'd)		
	5000-3224	1	Label: pushbutton .1 (-10)	-hp-	
	5000-3225	1	Label: pushbutton .3 (0)	-hp-	
	5000-3226	1	Label: pushbutton 1 (10)	-hp-	
	5000-3244	1	Label: pushbutton 3 (20)	-hp-	
	5000-3243	1	Label: pushbutton (CAL)	-hp-	
	5060-5973	1	Lead: ground	-hp-	
				-hp-	
	5020-0705	1	Meter trim: submodule	-hp-	
	03406-22111	1	Nut: boot probe	-hp-	
	8710-0084	1	Nut driver: hex	96508	P-3 obd
	03406-00207	1	Panel: front	-hp-	
	03406-04302	1	Panel: insert	-hp-	
	03406-00204	1	Panel: rear	-hp-	
	03406-00203	1	Panel: sub rear	-hp-	
	03406-00601	1	Shield: bottom cover	-hp-	
	03406-00604	1	Shield: probe filter cover	-hp-	
	03406-00603	1	Shield: range switch cover	-hp-	
	03406-22113	1	Shield: switch part of 03406-62102	-hp-	
	03406-00602	1	Shield: top cover	-hp-	
	1200-0168	2	Socket: TSTR (for Q1)	000LK	PTS-4
	1490-0032	1	Stand: tilt submodule	91260	obd
	7124-0339	1	Tag: red operating note	-hp-	
	5020-0457	10	Tip: pin probe	-hp-	
	11072-60002	1	Tip: isolator	-hp-	

SECTION VII
CIRCUIT DIAGRAMS

7-1. INTRODUCTION.

7-2. This section contains the circuit diagrams necessary for the operation and maintenance of the Model 3406A Broadband Sampling Voltmeter. Included is Table 7-1, with photograph of the instrument, identifying the various assemblies.

7-3. COVER REMOVAL.

7-4. To prepare the instrument for calibration or to make the components or test points on the top or bottom assemblies accessible perform the steps outlined in Figure 7-1.

7-5. FUNCTIONAL BLOCK DIAGRAM.

7-6. The functional block diagram shows the relationship between the assemblies of the instrument. Signal flow between assemblies and significant portions of assemblies as well as major feedback paths are shown. The functional block diagram is used to isolate trouble to a particular block. Test points, voltage waveforms, and voltage levels are identified on the functional block diagram.

7-7. COMPONENT LOCATION DIAGRAMS.

7-8. The component location diagrams show the physical location of parts mounted on an assembly. The components mounted on the chassis of the instrument are identified in Figure 7-2.

7-9. INTERCONNECTING ASSEMBLY.

7-10. The top and bottom assemblies are connected to each other and other circuits through the interconnecting assembly shown in Figure 7-3.

7-11. SCHEMATIC DIAGRAMS.

7-12. The circuits contained within each assembly are shown in a schematic diagram. These diagrams are used to develop an understanding of the detailed theory of operation and as an aid in isolating a malfunction to a component(s). To aid in troubleshooting dc voltage levels and waveform test points are given in red on each schematic.

7-13. An explanation of terms and symbols used on schematic diagrams is given below.

REFERENCE DESIGNATIONS

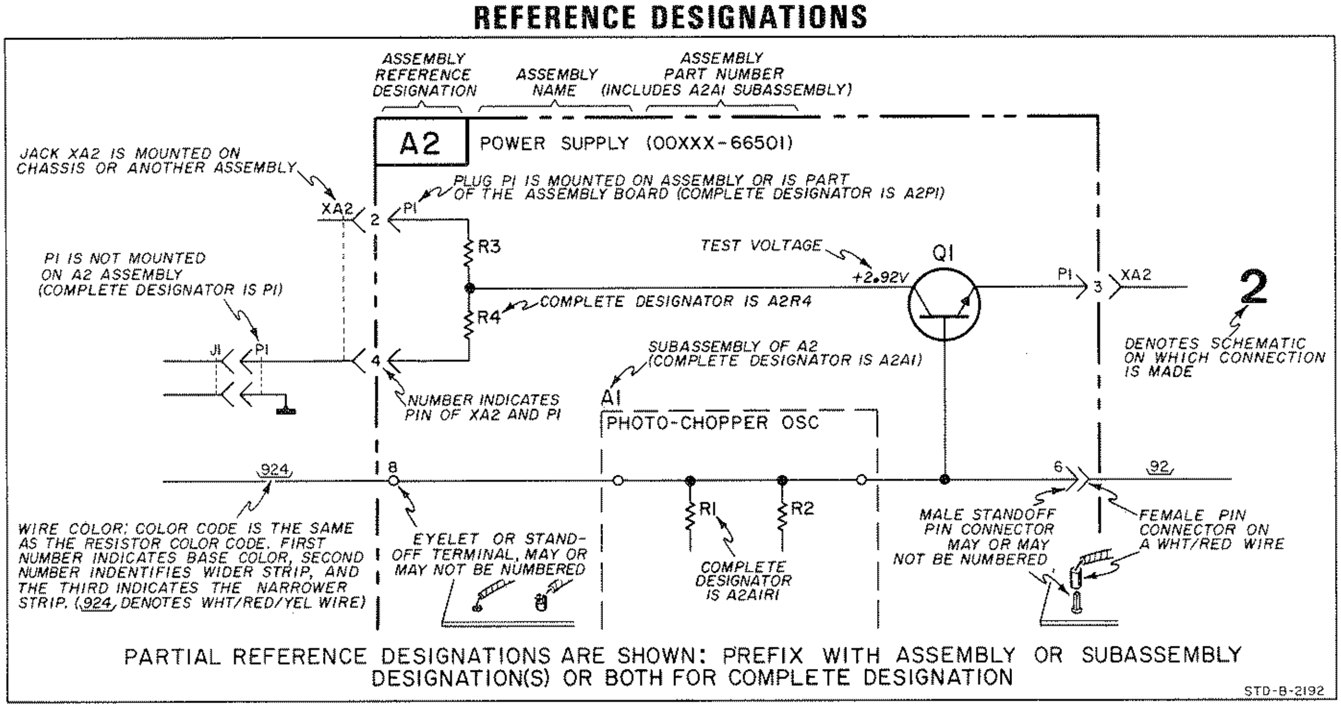


Table 7-1. Model 3406A Assembly Designations

REFERENCE DESIGNATION	TITLE	-hp- PART NO.	SCHEMATIC LOCATION
A1	Sampling Probe Assembly	03406-62104	Page 1
A2	Top Assembly	03406-66501	Page 1, 2
A3	Bottom Assembly	03406-66502	Page 1, 2, 3, and 4
S1	Range Switch Assembly	03406-61901	Page 1, 2, 3, and 4

NOTE

All components not located on one of the above assemblies are considered part of the "main" assembly and are not prefixed with an assembly reference designator.

PROBE REPLACEMENT

The Sampling Probe Assembly (A1) is not a field repairable item. A complete assembly is available on an exchange basis (-hp- Part No. 03406-62103) through your local Hewlett-Packard Sales and Service office (See Appendix B for office location).