

Errata

Title & Document Type: 4276A LCZ Meter Operating & Service Manual

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HP References in this Manual

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

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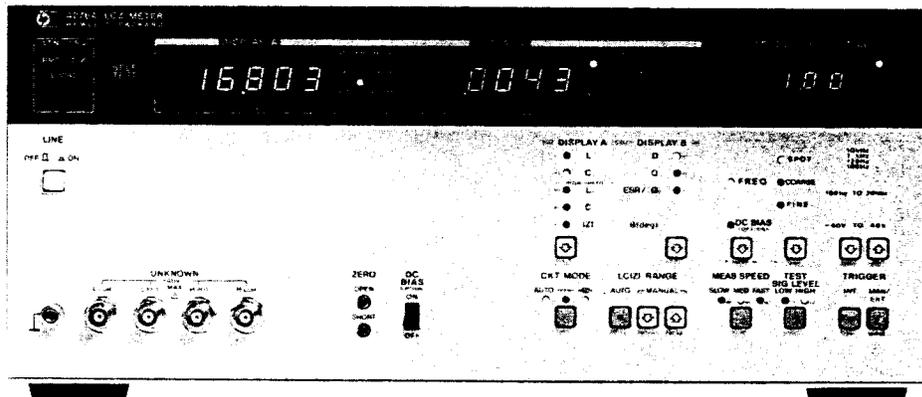
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OPERATION AND SERVICE MANUAL

4276A LCZ METER

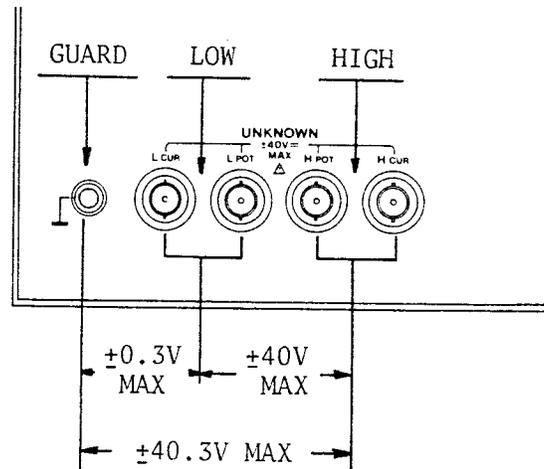


CAUTIONS ON OPERATION

USING EXTERNAL BIASING

When measuring any device that is biased from an external bias source, you must observe certain precautions to protect the 4276A's sensitive measurement circuitry.

- 1) DO NOT apply a dc bias voltage exceeding $\pm 40\text{V}$ between the LOW and HIGH UNKNOWN terminals as shown in the figure below.



Interterminal Bias Limitations

- 2) DO NOT, under any circumstances, connect a charged capacitor directly to the 4276A's UNKNOWN terminals.

If either of these precautions is ignored, the instrument may be damaged. Symptoms of the damage that may result are listed below.

- (1) No test signal at the H_{CUR} terminal
- (2) Excessive display fluctuation during measurement
- (3) During SELF TEST, error codes E37 through E39 and E41 through E45 are displayed on DISPLAY A.

If your 4276A exhibits these symptoms, contact the nearest Hewlett-Packard Sales and Service Office.

Note

When making impedance measurements on an active circuit or a device biased from an external source, set the DC BIAS slide switch on the rear panel to EXT and connect nothing to the EXT INPUT/INT MONITOR connector.

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 given 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.

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 the 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.

Herstellerbescheinigung

Hiermit wird bescheinigt, daß das Gerät HP 4276A (LCZ Meter) in Übereinstimmung mit den Bestimmungen von Postverfügung 1046/84 funkentstört ist.

Der Deutschen Bundespost wurde das Inverkehrbringen dieses Gerätes angezeigt und die Berechtigung zur Überprüfung der Serie auf Einhaltung der Bestimmungen eingeräumt.

Anm: Werden Meß- und Testgeräte mit ungeschirmten Kabeln und/oder in offenen Meßaufbauten verwendet, so ist vom Betreiber sicherzustellen, daß die Funk-Entstörbestimmungen unter Betriebsbedingungen an seiner Grundstücksgrenze eingehalten werden.

Manufacturer's Declaration

This is to certify that this product, the HP 4276A LCZ Meter, meets the radio frequency interference requirements of directive 1046/84. The German Bundespost has been notified that this equipment was put into circulation and was granted the right to check the product type for compliance with these requirements.

Note: If test and measurement equipment is operated with unshielded cables and/or used for measurements on open setups, the user must insure that under these operating conditions, the radio frequency interference limits are met at the border of his premises.

SAFETY SYMBOLS

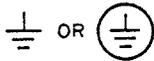
General Definitions of Safety Symbols Used On Equipment or In Manuals.



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.



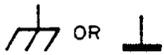
Indicates dangerous voltage (terminals fed from the interior by voltage exceeding 1000 volts must be so marked).



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 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

A **WARNING** 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

A **Note** denotes important information. It calls attention to a procedure, practice, condition or the like, which is essential to highlight.



OPERATION AND SERVICE MANUAL

MODEL 4276A

LCZ METER

(Including Options 001 and 002)

SERIAL NUMBERS

This manual applies directly to instruments with
serial numbers prefixed 2227J.

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SECTION I GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This operation and service manual contains the information required to install, operate, test, adjust, and service the Hewlett-Packard Model 4276A LCZ Meter. Figure 1-1 shows the instrument and its supplied accessories. This section covers specifications, instrument identification, description, options, accessories, and other basic information.

1-3. Listed on the title page of this manual is a microfiche part number. This number can be used to order 4 x 6 inch microfilm transparencies of the manual. Each microfiche contains up to 60 photo-duplicates of the manual pages. The microfiche package also includes the latest manual changes supplement as well as all pertinent service notes. To order an additional manual, use the part number listed on the title page of this manual.

1-4. DESCRIPTION

1-5. The HP Model 4276A LCZ Meter is a fully automatic, high performance test instrument designed to measure the inductance, capacitance, dissipation factor, quality factor, conductance, equivalent series resistance, impedance magnitude, and phase of electronic components and devices. Its built-in test signal source covers the frequency range of 100Hz to 20kHz and provides 801 spot frequencies. Test frequency resolution is 1Hz (maximum), and frequency accuracy is $\pm 0.01\%$ of the selected spot frequency. Frequently used spot frequencies--100Hz, 120Hz, 1kHz, and 10kHz--can be quickly selected by the SPOT key. Test signal level is selectable at 1Vrms (HIGH) or 50mVrms (LOW). In exceptional measurement ranges, the test signal in HIGH mode is 2Vrms. The instrument's 5 terminal configuratin provides a basic measurement accuracy of 0.1% over a wide measurement range.

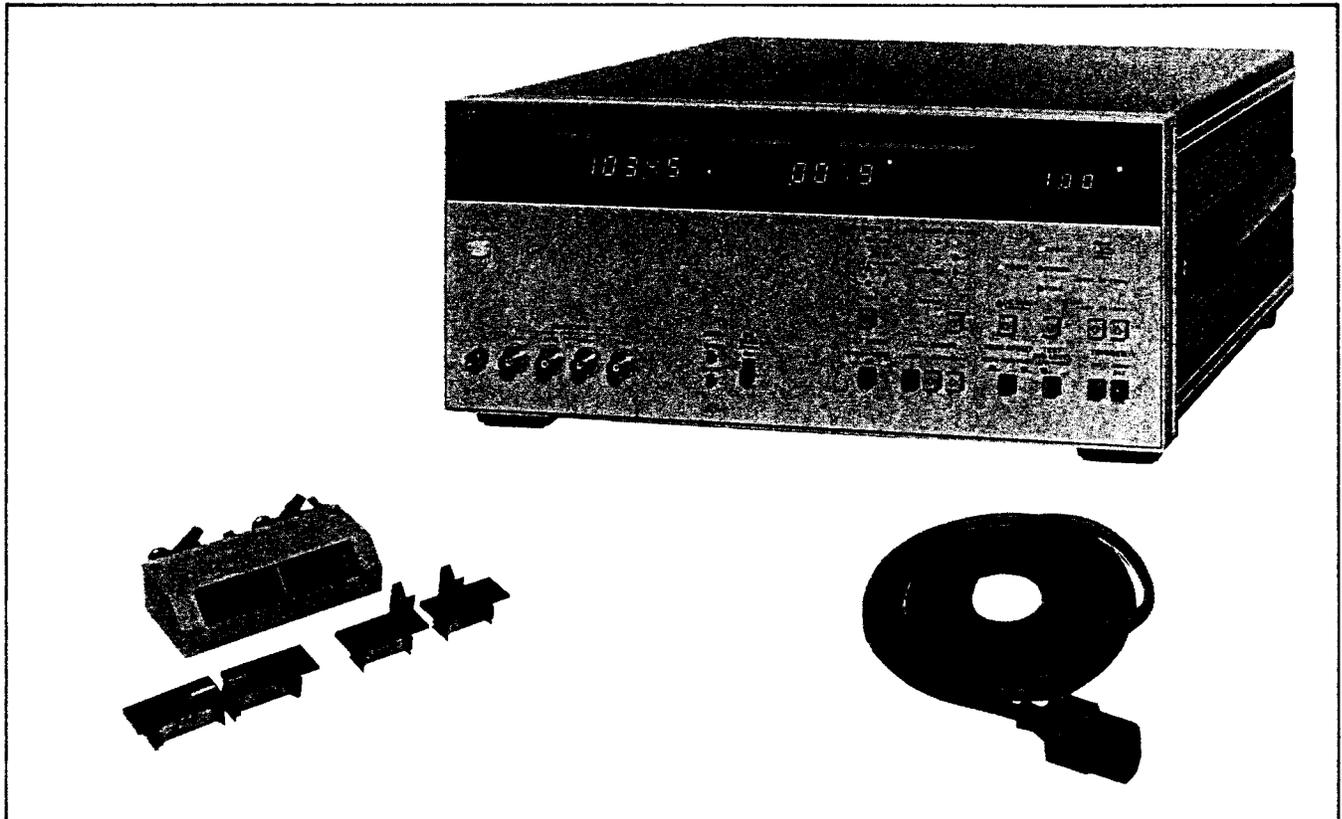


Figure 1-1. Model 4276A and Accessories.

SECTION I

1-6. The 4276A has three measurement speed modes: SLOW, MED, and FAST. When MED mode is selected, total time required for a C-D or L-Q measurement is approximately 100ms (at 1kHz). FAST mode measurement time is approximately 40 percent shorter than that of MED mode. Also, the HIGH SPEED C and HIGH SPEED L measurement functions reduce measurement time to approximately half that of a normal C-D or L-Q measurement. Shortest measurement time is approximately 25ms (HIGH SPEED C or L, FAST mode, at 20kHz). The 4276A is equipped with a Δ measurement function to permit temperature dependency or dc bias dependency measurements.

1-7. All instrument operations—measurement, front panel control settings, self test, continuous memory, etc.—are controlled by a Z80 microprocessor. The built-in self test function can be initiated at any time to verify correct operation of the instrument's basic capabilities. The 4276A is also equipped with a continuous memory function that is automatically activated when the instrument is turned off or experiences a power failure. All front panel control settings (except dc bias), zero offset data, and comparator limits (Option 002) are memorized and automatically recalled when the instrument is turned on again.

1-8. The Hewlett-Packard Interface Bus (HP-IB) is standard on the 4276A. All of the instrument's standard and optional functions (except power on/off and DC BIAS ON/OFF) can be remotely controlled from an HP-IB compatible controller. When set to TALK ONLY mode, the 4276A can send measurement data to an external device (a printer, for example) without a controller.

1-9. The 4276A can be equipped with two special options: Option 001 Internal DC Bias and Option 002 Comparator/Handler Interface. Refer to paragraph 1-21 for a brief description of these options.

1-10. A wide selection of accessories—test fixtures and test leads—is available. A description of furnished accessories is given in paragraph 1-30. For details on available accessories, refer to paragraph 1-32.

1-11. SPECIFICATIONS

1-12. Complete specifications of the Model 4276A are given in Table 1-1. These specifications are the performance standards or limits against which the instrument is tested. The test procedures for verifying the specifications are covered in Section IV,

Performance Tests. Table 1-2 lists supplemental performance characteristics. Supplemental performance characteristics are not specifications but are typical characteristics included as additional information for the operator. When the 4276A is shipped from the factory, it meets the specifications listed in Table 1-1.

1-13. SAFETY CONSIDERATIONS

1-14. The Model 4276A has been designed to conform to the safety requirements of an IEC (International Electromechanical Committee) Safety Class I instrument and is shipped from the factory in a safe condition.

1-15. This operating and service manual contains information, cautions, and warnings which must be followed by the user to ensure safe operation and to maintain the instrument in a safe condition.

1-16. INSTRUMENTS COVERED BY MANUAL

1-17. Hewlett-Packard uses a two-section nine character serial number which is stamped on the serial number plate (Figure 1-2) attached to the instrument's rear-panel. The first four digits and the letter are the serial prefix and the last five digits are the suffix. The letter placed between the two sections identifies the country where the instrument was manufactured. The prefix is the same for all identical instruments; it changes only when a change is made to the instrument. The suffix, however, is assigned sequentially and is different for each instrument. The contents of this manual apply to instruments with the serial number prefix(es) listed under SERIAL NUMBERS on the title page.

1-18. An instrument manufactured after the printing of this manual may have a serial number prefix that is not listed on the title page. This unlisted serial number prefix indicates the instrument is different from the one described in this manual. The manual for this newer instrument may be accompanied by a yellow Manual Changes supplement or have a different manual part number. This supplement contains "change information" that explains how to adapt the manual to the newer instrument.

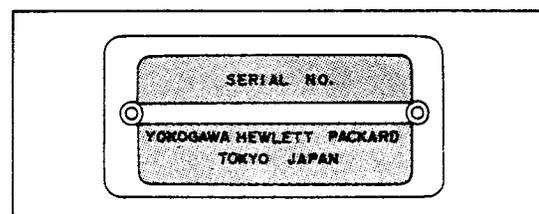


Figure 1-2. Serial Number Plate.

Table 1-1. Specifications (Sheet 1 of 14)

Specifications

Parameters Measured:

C (capacitance), L (inductance), $|Z|$ (impedance), D (dissipation factor), Q (quality factor), ESR (equivalent series resistance), G (conductance), θ (phase angle), HIGH SPEED C, HIGH SPEED L, Δ (deviation)

Parameter Combinations:

| Circuit Mode | Parameter Combination |
|---|---|
| Series  | C-D, C-Q, C-ESR, L-D, L-Q, L-ESR, $ Z - \theta$, HIGH SPEED C, HIGH SPEED L |
| Parallel  | C-D, C-Q, C-G, L-D, L-Q, L-G, $ Z - \theta$, HIGH SPEED C, HIGH SPEED L |

Measurement Circuit Modes:

Auto, Series () , and Parallel ()

Measurement Speed Modes:

SLOW, MED, and FAST

Displays:

| Measurement Speed Mode | Display Digits | Maximum Display |
|------------------------|----------------|-----------------|
| SLOW | 4 1/2 | 19999 counts |
| MED | | |
| FAST | 3 1/2 | 1999 counts |

Note

Number of display digits depends on the test frequency, the test signal level, and the measurement range.

Measurement Terminals:

5-terminal configuration with guard terminal

Ranging Modes:

Auto and Manual (UP/DOWN keys)

Test Frequencies:

| Test Frequency Range | Reduction |
|----------------------|-----------|
| 100Hz to 200Hz | 1Hz |
| 200Hz to 500Hz | 2Hz |
| 500Hz to 1kHz | 5Hz |
| 1kHz to 2kHz | 10Hz |
| 2kHz to 5kHz | 20Hz |
| 5kHz to 10kHz | 50Hz |
| 10kHz to 20kHz | 100Hz |

Frequency Control Modes:

SPOT (100Hz, 120Hz, 1kHz, 10kHz)
COARSE (10 Freq. points/decade)
FINE (Maximum resolution)

Frequency Accuracy: $\pm 0.01\%$

Test Signal Level:

HIGH (1Vrms) or LOW (50mVrms)

Note

HIGH test signal level is 2Vrms on the ranges shown in Tables A and B.

Table A.

| Capacitance Range | Test Frequency Range | | |
|-------------------|----------------------|------------------|---------------|
| | 100Hz to 199Hz | 200Hz to 1.99kHz | 2kHz to 20kHz |
| 10mF | | | |
| 1mF | | 2Vrms | |
| 100 μ F | | | |
| 10 μ F | | | |
| 1 μ F | | | |
| 100nF | | 1Vrms | |
| 10nF | | | |
| 1nF | | | |
| 100pF | | | |
| 10pF | | | |

Note: C Measurement in Series CKT Mode

Table 1-1. Specifications (Sheet 2 of 14)

Table B.

| Impedance Range | Test Frequency Range |
|-----------------|----------------------|
| | |
| 10MΩ | 1Vrms |
| 1MΩ | |
| 100kΩ | |
| 10kΩ | |
| 1kΩ | |
| 100Ω | |
| 10Ω | |
| 1Ω | |
| 100mΩ | |

Note: |Z| Measurement

Level Accuracy:

| Test Signal Level | Test Frequency | |
|-------------------|----------------|-----------------|
| | 1kHz | Other than 1kHz |
| HIGH | ±10% | ±50% |
| LOW | ±20% | |

Output Impedance: 100Ω±20%

Deviation Measurement:

Calculates and displays the difference between stored reference values and measured values.

ZERO Offset Adjustment:

Compensation for residual impedance and stray admittance of the test fixture connected to the UNKNOWN terminals is automatically done by the ZERO OPEN/SHORT buttons.

* Compensation frequencies:
20kHz, 16kHz, 10kHz, 5kHz, 2kHz, 1kHz, 500Hz, 200Hz, and 100Hz. Compensation at other frequencies is automatically done by secondary interpolation.

* Maximum offset values:
C: Up to 20pF (OPEN)
G: Up to .2μS (OPEN)
|Z|: Up to 2Ω (SHORT)

SELF TEST:

Checks the 4276A's basic operation when the instrument is turned on or when the SELF TEST key is pressed. If an abnormality is detected, an error code is displayed on DISPLAY A.

External DC Bias:

Up to ±40V dc can be applied to the DUT from an external voltage source connected to the EXT INPUT/INT MONITOR BNC connector on the rear-panel.

Output impedance is 1020Ω±10%.

Trigger:

Internal, External, Manual, or HP-IB remote control

HP-IB (Hewlett-Packard Interface Bus):

Data output and remote control. Based on IEEE Std 488 and ANSI-MC1.1.

Interface Capabilities:

SH1, AH1, T5, L4, SR1, RL1, DC1, DT1, and E1

Remote Control:

All front panel control settings (except power switch, and DC BIAS ON/OFF switch) and all 16064A Comparator/Handler Interface settings (option 002)

Data Output:

Parameter measured, equivalent circuit mode, display status, measured values, and comparator output. Output format is ASCII format or Binary Packed format.

Continuous Memory:

Memorizes all front panel control settings (except DC BIAS voltage setting), zero offset adjustment data, reference values, and comparator limits (option 002) when the instrument is turned off or experiences a power failure. Settings and data are recalled when the instrument is turned on.

Warm-up Time: Maximum 30minutes

Ambient Temperature:

23 °C±5 °C (At 0 °C to 55 °C, error doubles)

Table 1-1. Specifications (Sheet 3 of 14)

CAPACITANCE MEASUREMENT ACCURACY

C-D Measurement Accuracy:

C Accuracy: $\pm[(\% \text{ of reading}) + (\text{number of counts})]$, see Tables A-1 and A-2.

D Accuracy: $\pm[(\% \text{ of reading}) + (\text{D error}) + (\text{number of counts})]$, see Tables A-1 and A-2.

Note: Use Table A-1 when the test frequency is 100Hz, 120Hz, 1kHz, and 10kHz. Use Table A-2 for all other frequencies.

C-Q Measurement Accuracy:

C Accuracy: $\pm[(\text{C accuracy of C-D measurement})]$

Q Accuracy: $\pm[(\text{D accuracy} \div \text{measured D value} \times 100)\% \text{ of Q reading} + 1 \text{ count}]$

Note: Q is the reciprocal of D.

Note: Q accuracy is calculated from the measured D value. Refer to Figure 3-16.

Table A-1. C-D Accuracies (100Hz, 120Hz, 1kHz, 10kHz only)

| Capacitance Range | Test Frequency Range | | |
|-------------------|--|---|---|
| | 100Hz and 120Hz | 1kHz | 10kHz |
| 10mF | $3\% + \frac{4}{.03} + \underline{6}$ | | |
| 1mF | $.75\% + \frac{2}{.015} + \underline{3}$ | $2\% + \frac{4}{.02} + \underline{6}$ | |
| 100μF | $.45\% + \frac{2}{.015} + \underline{3}$ | $.5\% + \frac{2}{.01} + \underline{3}$ | $3\% + \frac{2}{.03} + \underline{3}$ |
| 10μF | | $.3\% + \frac{2}{.01} + \underline{3}$ | $1.5\% + \frac{2}{.03} + \underline{3}$ |
| 1μF | $.15\% + \frac{5}{.0009A} + \underline{5}$ | | $.9\% + \frac{2}{.03} + \underline{3}$ |
| 100nF | | $.1\% + \frac{5}{.0006A} + \underline{5}$ | $.3\% + \frac{5}{.0018A} + \underline{5}$ |
| 10nF | | | |
| 1nF | $.45\% + \frac{5}{.0045A} + \underline{5}$ | | $.6\% + \frac{10}{.0036A} + \underline{10}$ |
| 100pF | | $.3\% + \frac{5}{.003A} + \underline{5}$ | |
| 10pF | | | $1.2\% + \frac{4}{.0036A} + \underline{6}$ |

Table 1-1. Specifications (Sheet 4 of 14)

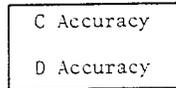
Table A-2. C-D Accuracies

| Capacitance Range | Test Frequency Range | | | | | |
|-------------------|----------------------|----------------|----------------|--------------------|-----------------|-----------------|
| | 101Hz to 199Hz* | 200Hz to 496Hz | 500Hz to 995Hz | 1.01kHz to 1.99kHz | 2kHz to 4.98kHz | 5kHz to 9.95kHz |
| 10mF | | | | | | |
| 1mF | | | | | | |
| 100µF | | | | | | |
| 10µF | | | | | | |
| 1µF | | | | | | |
| 100nF | | | | | | |
| 10nF | | | | | | |
| 1nF | | | | | | |
| 100pF | | | | | | |
| 10pF | | | | | | |

| Capacitance Range | 101Hz to 199Hz* | 200Hz to 496Hz | 500Hz to 995Hz | 1.01kHz to 1.99kHz | 2kHz to 4.98kHz | 5kHz to 9.95kHz | 10.1kHz to 20kHz |
|-------------------|-----------------|----------------|----------------|--------------------|-----------------|-----------------|------------------|
| 10mF | | | | | | | |
| 1mF | | | | | | | |
| 100µF | | | | | | | |
| 10µF | | | | | | | |
| 1µF | | | | | | | |
| 100nF | | | | | | | |
| 10nF | | | | | | | |
| 1nF | | | | | | | |
| 100pF | | | | | | | |
| 10pF | | | | | | | |

* Except 120Hz

Equations in Tables A-1 and A-2 represent



α : Full-scale factor (= measured C value ÷ full-scale C value). For example, when the measured C value is 850pF on the 1000pF range, α is 0.85.

$A = [\alpha + (1/\alpha)]/2$

Note 1: Tables A-1 and A-2 are applicable under the following conditions:

- (1) Test Signal Level: HIGH
- (2) Measurement Speed: MED or SLOW
- (3) Sample's D Value: ≤ 0.1
- (4) Zero offset adjustment has been performed with the OPEN and SHORT terminations of the Model 16074A.

Note 2: Error doubles when LOW test signal level (50mVrms) is used. LOW test signal level can be used only on the ranges enclosed in the bold line in Tables A-1 and A-2.

Note 3: When FAST measurement speed is used, accuracies double on the ranges outside the area enclosed in the bold line in Tables A-1 and A-2.

HIGH SPEED C Measurement Accuracy:

C Accuracy: $\pm[(C \text{ accuracy of C-D measurement}) + (X\% \text{ of reading})]$, see Table A-3.

Note: HIGH SPEED C accuracy is specified on the ranges enclosed in the dotted line in Tables A-1 and A-2.

Table A-3. Additional Error

| Test Signal Level | Sample's D Value | | | |
|-------------------|------------------|-----------------------|--------------------|----------------|
| | $D \leq .0004$ | $.0004 < D \leq .002$ | $.002 < D \leq .1$ | $D > .1$ |
| HIGH | X = 0 | | X = 20D | Not specified. |
| LOW | X = 0 | X = 100D | | |

Note: Table A-3 is applicable under the following condition:

- (1) Zero offset adjustment has been performed with the OPEN and SHORT terminations of the Model 16074A.

Table 1-1. Specifications (Sheet 5 of 14)

C-ESR/G Measurement Accuracy:

C Accuracy: $\pm[(C \text{ accuracy of C-D measurement})]$

ESR Accuracy: $\pm[(\% \text{ of reading}) + (\text{ESR error in ohms}), \text{ see Tables A-4 and A-5.}]$

G Accuracy: $\pm[(\% \text{ of reading}) + (\text{G error in siemens}) + (\text{number of counts})]$, see Tables A-4 and A-5.

Note: Use Table A-4 when the test frequency is 100Hz, 120Hz, 1kHz, or 10kHz. Use Table A-5 for all other frequencies.

Note: ESR range and G range depend on the selected C range and test frequency. Refer to Table A-6.

Note: DISPLAY B function, when ESR/G is selected, depends on the CIRCUIT MODE.

Table A-4. C-ESR/G Accuracies (100Hz, 120Hz, 1kHz, 10kHz only)

| ESR/G Range | | Test Frequency Range | | |
|-------------|---------------|---|--|--|
| | | 100Hz and 120Hz | 1kHz | 10kHz |
| ESR | 10M Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 1 μ S | .6% + 6 α nS + <u>5</u> | .3% + 3 α nS + <u>5</u> | 1.2% + 12 α nS + <u>4</u> |
| ESR | 1M Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 10 μ S | .2% + 40 α nS + <u>5</u> | .1% + 20 α nS + <u>5</u> | .6% + .12 α μ S + <u>10</u> |
| ESR | 100k Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 100 μ S | .2% + .4 α μ S + <u>5</u> | .1% + .2 α μ S + <u>5</u> | .6% + 1.2 α μ S + <u>10</u> |
| ESR | 10k Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 1mS | .2% + 4 α μ S + <u>5</u> | .1% + 2 α μ S + <u>5</u> | .3% + 6 α μ S + <u>5</u> |
| ESR | 1k Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 10mS | .2% + 40 α μ S + <u>5</u> | .1% + 20 α μ S + <u>5</u> | .3% + 60 α μ S + <u>5</u> |
| ESR | 100 Ω | .4% + .4/ α Ω + <u>5</u> | .2% + .2/ α Ω + <u>5</u> | .6% + .6/ α Ω + <u>5</u> |
| G | 100mS | See Note 2 | See Note 2 | See Note 2 |
| ESR | 10 Ω | 1% + .1/ α Ω + <u>2</u> | .5% + 50/ α m Ω + <u>2</u> | 1.5% + .15/ α Ω + <u>2</u> |
| G | 1S | See Note 2 | See Note 2 | See Note 2 |
| ESR | 1 Ω | 2% + 20/ α m Ω + <u>2</u> | 1% + 10/ α m Ω + <u>2</u> | 3% + 30/ α m Ω + <u>2</u> |
| G | 10S | See Note 2 | See Note 2 | See Note 2 |

Table 1-1. Specifications (Sheet 6 of 14)

Table A-5. C-ESR/G Accuracies

| ESR/G Range | | Test Frequency Range | | | | | | |
|-------------|-------|-----------------------|----------------|------------------------|-----------------------|-----------------|--------------------------|--------------------------|
| | | 101Hz to 199Hz* | 200Hz to 498Hz | 500Hz to 995Hz | 1.01kHz to 1.99kHz | 2kHz to 4.98kHz | 5kHz to 9.95kHz | 10.1kHz to 20kHz |
| ESR | 10MΩ | See Note 1 | | See Note 1 | See Note 1 | | See Note 1 | See Note 1 |
| G | 1μS | .6% + 6αnS + <u>5</u> | | .4% + 4αnS + <u>2</u> | .6% + 6αnS + <u>5</u> | | 1.2% + 12αnS + <u>4</u> | 2% + 20αnS + <u>4</u> |
| ESR | 1MΩ | | | See Note 1 | | | See Note 1 | See Note 1 |
| G | 10μS | | | .2% + 40αnS + <u>5</u> | | | .6% + .12αμS + <u>10</u> | 2% + .4αμS + <u>20</u> |
| ESR | 100kΩ | | | See Note 1 | | | See Note 1 | See Note 1 |
| G | 100μS | | | .2% + .4αμS + <u>5</u> | | | .6% + 1.2αμS + <u>10</u> | 1% + 2αμS + <u>10</u> |
| ESR | 10kΩ | | | See Note 1 | | | See Note 1 | See Note 1 |
| G | 1mS | | | .2% + 4αμS + <u>5</u> | | | .3% + 6αμS + <u>5</u> | .5% + 10αμS + <u>5</u> |
| ESR | 1kΩ | | | See Note 1 | | | See Note 1 | See Note 1 |
| G | 10mS | | | .2% + 40αμS + <u>5</u> | | | .3% + 60αμS + <u>5</u> | .5% + .1αmS + <u>5</u> |
| ESR | 100Ω | | | .4% + .4/αΩ + <u>5</u> | | | .6% + .6/αΩ + <u>5</u> | 1% + 1/αΩ + <u>5</u> |
| G | 100mS | | | See Note 2 | | | See Note 2 | See Note 2 |
| ESR | 10Ω | | | 1% + .1/αΩ + <u>2</u> | | | 1.5% + .15/αΩ + <u>2</u> | 2.5% + .25/αΩ + <u>2</u> |
| G | 1S | | | See Note 2 | | | See Note 2 | See Note 2 |
| ESR | 1Ω | | | 2% + 20/αmΩ + <u>2</u> | | | 3% + 30/αmΩ + <u>2</u> | 5% + 50/αmΩ + <u>2</u> |
| G | 10S | | | See Note 2 | | | See Note 2 | See Note 2 |

* Except 120Hz

Equations in Tables A-4 and A-5 represent:

| |
|--------------|
| ESR Accuracy |
| G Accuracy |

α: Full-scale factor (= measured C value ÷ full-scale C value). For example, when the measured C value is 850pF on the 1000pF range, α is 0.85.

Note 1: ESR accuracy is ±[2 (C accuracy ÷ measured C x 100)% of ESR reading + (G accuracy ÷ measured G x 100)% of ESR reading + 1 count].

Note 2: G accuracy is ±[2 (C accuracy ÷ measured C x 100)% of G reading + (ESR accuracy ÷ measured ESR x 100)% of G reading] + 1 count].

Note 3: Tables A-4 and A-5 are applicable under the following conditions:

- (1) Test Signal Level: HIGH
- (2) Measurement Speed Mode: MED or SLOW
- (3) Sample's D Value: ≤ 0.1
- (4) Zero offset adjustment has been performed with the OPEN and SHORT terminations of the Model 16074A.

Note 4: Error doubles when LOW test signal level (50mVrms) is used. LOW test signal level can be used only on the ranges enclosed in the bold line in Tables A-4 and A-5.

Note 5: When FAST measurement speed is used, accuracies double on the ranges outside the area enclosed in the bold line in Tables A-4 and A-5.

Table A-6. ESR/G Range Selection

| Capacitance Range | Test Frequency Range | | | | | | |
|-------------------|----------------------|----------------|------------------|-----------------|---------------|------|--|
| | 100Hz to 199Hz | 200Hz to 498Hz | 500Hz to 1.99kHz | 2kHz to 4.98kHz | 5kHz to 20kHz | | |
| 10mF | | | | | | | |
| 1mF | | | 1Ω | | | | |
| | | | 10S | | | | |
| 100μF | | | 10Ω | | | | |
| | | | 1S | | | | |
| 10μF | | | 100Ω | | | | |
| | | | 100mS | | | | |
| 1μF | | | 1kΩ | | | | |
| | | | 10mS | | | | |
| 100nF | | | 10kΩ | | | | |
| | | | 1mS | | | | |
| 10nF | | | 100kΩ | | | | |
| | | | 100μS | | | | |
| 1nF | 10MΩ | | 1MΩ | | | | |
| | 1μS | | 10μS | | | | |
| 100pF | | | 10MΩ | | | | |
| | | | 1μS | | | | |
| 10pF | | | | | | 10MΩ | |
| | | | | | | 1μS | |

Table 1-1. Specifications (Sheet 7 of 14)

INDUCTANCE MEASUREMENT ACCURACY

L-D Measurement Accuracy:

L Accuracy: $\pm[(\% \text{ of reading}) + (\text{L error}) + (\text{number of counts})]$, see Tables B-1 and B-2.

D Accuracy: $\pm[(\% \text{ of reading}) + (\text{D error}) + (\text{number of counts})]$, see Tables B-1 and B-2.

Note: Use Table B-1 when the test frequency is 100Hz, 120Hz, 1kHz, or 10kHz. Use Table B-2 for all other frequencies.

L-Q Measurement Accuracy:

L Accuracy: $\pm[(\text{L accuracy of L-D measurement})]$

Q Accuracy: $\pm[(\text{D accuracy} \div \text{measured D value} \times 100)\% \text{ of Q reading} + 1 \text{ count}]$

Note: Q value is the reciprocal of D.

Note: Q accuracy is calculated from the measured D value. Refer to Figure 3-15.

Table B-1. L-D Accuracies (100Hz, 120Hz, 1kHz, 10kHz only)

| Inductance Range | Test Frequency Range | | |
|------------------|---|---|--|
| | 100Hz and 120Hz | 1kHz | 10kHz |
| 1kH | $(1 + \alpha)\% + \frac{2}{2\% + .02 + \frac{2}{2}}$ | | |
| 100H | | $.5 (1 + \alpha)\% + \frac{2}{1\% + .01 + \frac{2}{2}}$ | |
| 10H | $.4 (1 + \alpha)\% + \frac{2}{.8\% + .02 + \frac{2}{2}}$ | | $1.5 (1 + \alpha)\% + \frac{2}{3\% + .03 + \frac{2}{2}}$ |
| 1H | | $.2 (1 + \alpha)\% + \frac{2}{.4\% + .01 + \frac{2}{2}}$ | |
| 100mH | $.4\% + \frac{5}{.6\% + \frac{.006}{\alpha} + \frac{5}{5}}$ | | $.6 (1 + \alpha)\% + \frac{2}{1.2\% + .03 + \frac{2}{2}}$ |
| 10mH | $.6\% + \frac{5}{.8\% + \frac{.008}{\alpha} + \frac{5}{5}}$ | $.2\% + \frac{5}{.3\% + \frac{.003}{\alpha} + \frac{5}{5}}$ | |
| 1mH | | $.3\% + \frac{5}{.4\% + \frac{.004}{\alpha} + \frac{5}{5}}$ | $.6\% + \frac{5}{.9\% + \frac{.009}{\alpha} + \frac{5}{5}}$ |
| 100μH | | | $.9\% + \frac{5}{1.2\% + \frac{.012}{\alpha} + \frac{5}{5}}$ |

Table 1-1. Specifications (Sheet 8 of 14)

Table B-2. L-D Accuracies

| Inductance Range | Test Frequency Range | | | |
|------------------|----------------------|--------------------|-----------------|------------------|
| | 101Hz to 995Hz* | 1.01kHz to 4.98kHz | 5kHz to 9.95kHz | 10.1kHz to 20kHz |
| 1KH | | | | |
| 100H | | | | |
| 10H | | | | |
| 1H | | | | |
| 100mH | | | | |
| 10mH | | | | |
| 1mH | | | | |
| 100uH | | | | |

* Except 120Hz

Equations in Tables B-1 and B-2 represent:

| |
|------------|
| L Accuracy |
| D Accuracy |

α : Full-scale factor (= measured L value ÷ full-scale L value). For example, when the measured L is 850nH on the 1000nH range, α is 0.85.

Note 1: Tables B-1 and B-2 are applicable under the following conditions:

- (1) Test Signal Level: HIGH

- (2) Measurement Speed Mode: MED or SLOW

- (3) Sample's D Value: ≤ 0.1

- (4) Zero offset adjustment has been performed with the OPEN and SHORT terminations of the Model 16074A.

Note 2: When FAST measurement speed is used, accuracies double on the ranges outside the area enclosed in the bold line in Tables B-1 and B-2.

Note 3: LOW test signal level cannot be used in L measurement mode.

HIGH SPEED L Measurement Accuracy:

L Accuracy: $\pm[(L \text{ accuracy of L-D measurement}) + (Y\% \text{ of reading})]$, see Table B-3.

Note: HIGH SPEED L accuracy is specified on the ranges enclosed in the dotted line in Tables B-1 and B-2.

Table B-3. Additional Error

| Test Signal Level | Sample's D Value | | | D > .1 |
|-------------------|------------------|-----------------------|--------------------|----------------|
| | D \leq .0004 | .0004 < D \leq .002 | .002 < D \leq .1 | |
| HIGH | Y = 0 | | Y = 20D | Not specified. |

Note: Table B-3 is applicable under the following conditions:

- (1) Zero offset adjustment has been performed with the OPEN and SHORT terminations of the Model 16074A.

Note: LOW test signal level cannot be used in L measurement mode.

Table 1-1. Specifications (Sheet 9 of 14)

L-ESR/G Measurement Accuracy:

L Accuracy: $\pm[(L \text{ accuracy of L-D measurement})]$

ESR Accuracy: $\pm[(\% \text{ of reading}) + (\text{ESR error in ohms}) + (\text{number of counts})]$, see Tables B-4 and B-5.

G Accuracy: $\pm[(\% \text{ of reading}) + (\text{G error in siemens}) + (\text{number of counts})]$, see Tables B-4 and B-5.

Note: Use Table B-4 when the test frequency is 100Hz, 120Hz, 1kHz, or 10kHz. Use Table B-5 for all other frequencies.

Note: ESR range and G range depend on the selected L range and test frequency. Refer to Table B-6.

Note: DISPLAY B function, when ESR/G is selected, depends on the CIRCUIT MODE.

Table B-4. L-ESR/G Accuracies (100Hz, 120Hz, 1kHz, 10kHz only)

| ESR/G Range | | Test Frequency Range | | |
|-------------|---------------|--|--|--|
| | | 100Hz and 120Hz | 1kHz | 10kHz |
| ESR | 1M Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 10 μ S | .4% + 40/ α nS + <u>2</u> | .2% + 20/ α nS + <u>2</u> | 1.2% + .12/ α μ S + <u>4</u> |
| ESR | 100k Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 100 μ S | .4% + .4/ α μ S + <u>5</u> | .2% + .2/ α μ S + <u>5</u> | 1.2% + 1.2/ α μ S + <u>10</u> |
| ESR | 10k Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 1mS | .4% + 4/ α μ S + <u>5</u> | .2% + 2/ α μ S + <u>5</u> | .6% + 6/ α μ S + <u>5</u> |
| ESR | 1k Ω | See Note 1 | See Note 1 | See Note 1 |
| G | 10mS | .4% + 40/ α μ S + <u>5</u> | .2% + 20/ α μ S + <u>5</u> | .6% + 60/ α μ S + <u>5</u> |
| ESR | 100 Ω | .2% + .4 α Ω + <u>5</u> | .1% + .2 α Ω + <u>5</u> | .3% + .6 α Ω + <u>5</u> |
| G | 100mS | See Note 2 | See Note 2 | See Note 2 |
| ESR | 10 Ω | .6% + 60 α m Ω + <u>10</u> | .3% + 30 α m Ω + <u>10</u> | .9% + 90 α m Ω + <u>10</u> |
| G | 1S | See Note 2 | See Note 2 | See Note 2 |

Table 1-1. Specifications (Sheet 10 of 14)

Table B-5. L-ESR/G Accuracies

| ESR/G Range | | Test Frequency Range | | |
|-------------|-------|-------------------------|----------------------------|--------------------------|
| | | 101Hz to 4.98kHz* | 5kHz to 9.95kHz | 10.1kHz to 20kHz |
| ESR | 1MΩ | See Note 1 | See Note 1 | See Note 1 |
| G | 10μS | .4% + 40/αnS + <u>2</u> | 1.2% + .12/αμS + <u>4</u> | 4% + .4/αμS + <u>8</u> |
| ESR | 100kΩ | See Note 1 | See Note 1 | See Note 1 |
| G | 100μS | .4% + .4/αμS + <u>5</u> | 1.2% + 1.2/αμS + <u>10</u> | 2% + 2/αμS + <u>10</u> |
| ESR | 10kΩ | See Note 1 | See Note 1 | See Note 1 |
| G | 1mS | .4% + 4/αμS + <u>5</u> | .6% + 6/αμS + <u>5</u> | 1% + 10/αμS + <u>5</u> |
| ESR | 1kΩ | See Note 1 | See Note 1 | See Note 1 |
| G | 10mS | .4% + 40/αμS + <u>5</u> | .6% + 60/αμS + <u>5</u> | 1% + 100/αμS + <u>5</u> |
| ESR | 100Ω | .2% + .4αΩ + <u>5</u> | .3% + .6αΩ + <u>5</u> | .5% + αΩ + <u>5</u> |
| G | 100mS | See Note 2 | See Note 2 | See Note 2 |
| ESR | 10Ω | .6% + 60αmΩ + <u>10</u> | .9% + 90αmΩ + <u>10</u> | 1.5% + .15αΩ + <u>10</u> |
| G | 1S | See Note 2 | See Note 2 | See Note 2 |

* Except 120Hz and 1kHz

Equations in Tables B-4 and B-5 represent:

| |
|--------------|
| ESR Accuracy |
| G Accuracy |

α: Full-scale factor (= measured L value ÷ full-scale L value). For example, when measured C value is 850nH on the 1000nH range, α is 0.85.

Note 1: ESR accuracy is ±[(L accuracy ÷ measured L x 100)% of ESR reading + (G accuracy ÷ measured G x 100)% of ESR reading + 1 count].

Note 2: G accuracy is ±[2 (L accuracy ÷ measured L x 100)% of G reading + (ESR accuracy ÷ measured ESR x 100)% of G reading + 1 count].

Note 3: Tables B-4 and B-5 are applicable under the following conditions:

- (1) Test Signal Level: HIGH
- (2) Measurement Speed Mode: MED or SLOW
- (3) Sample's D Value: ≤ 0.1
- (4) Zero offset adjustment has been performed with the OPEN and SHORT terminations of the Model 16074A.

Note 4: When FAST measurement speed is used, accuracies double on the ranges outside the area enclosed in the bold line in Tables B-4 and B-5.

Note 5: LOW test signal level cannot be used in L measurement mode.

Table B-6. ESR/G Range Selection

| Inductance Range | Test Frequency Range | | |
|------------------|----------------------|-----------------|----------------|
| | 100Hz to 995Hz | 1kHz to 9.95kHz | 10kHz to 20kHz |
| 1kH | | | |
| 100H | | 1MΩ 10μS | |
| 10H | | 100kΩ 100μS | |
| 1H | | 10kΩ 1mS | |
| 100mH | | 1kΩ 10mS | |
| 10mH | | 100Ω 100mS | |
| 1mH | | 10Ω 1S | |
| 100μH | | | |

Table 1-1. Specifications (Sheet 11 of 14)

IMPEDANCE MEASUREMENT ACCURACY

$|Z| - \theta$ Measurement Accuracy:

$|Z|$ Accuracy: $\pm[(\% \text{ of reading}) + (\text{number of counts})]$, see Tables C-1 and C-2.

θ Accuracy: $\pm[(\theta \text{ error in degrees}) + (\text{number of counts})]$, see Tables C-1 and C-2.

Note: Use Table C-1 when the test frequency is 100Hz, 120Hz, 1kHz, or 10kHz. Use Table C-2 for all other frequencies.

Table C-1. $|Z| - \theta$ Accuracies (100Hz, 120Hz, 1kHz, 10kHz only)

| Impedance Range | Test Frequency Range | | |
|-----------------|--|------|--|
| | 100Hz and 120Hz | 1kHz | 10kHz |
| 10M Ω | $(1 + \alpha)\% + \frac{2}{(1 + \alpha)^\circ + \frac{2}{}}$ | | $2(1 + \alpha)\% + \frac{2}{2(1 + \alpha)^\circ + \frac{2}{}}$ |
| 1M Ω | $.5(1 + \alpha)\% + \frac{2}{.5(1 + \alpha)^\circ + \frac{2}{}}$ | | $(1 + \alpha)\% + \frac{2}{(1 + \alpha)^\circ + \frac{2}{}}$ |
| 100k Ω | | | |
| 10k Ω | $.2(1 + \alpha)\% + \frac{2}{.2(1 + \alpha)^\circ + \frac{2}{}}$ | | $.4(1 + \alpha)\% + \frac{2}{.4(1 + \alpha)^\circ + \frac{2}{}}$ |
| 1k Ω | | | |
| 100 Ω | $.1\% + \frac{5}{.1/\alpha^\circ + \frac{5}{}}$ | | $.2\% + \frac{5}{.2/\alpha^\circ + \frac{5}{}}$ |
| 10 Ω | $.3\% + \frac{5}{.3/\alpha^\circ + \frac{5}{}}$ | | $.6\% + \frac{5}{.6/\alpha^\circ + \frac{5}{}}$ |
| 1 Ω | $.7\% + \frac{2}{.5/\alpha^\circ + \frac{2}{}}$ | | $1.4\% + \frac{2}{1/\alpha^\circ + \frac{2}{}}$ |
| 100m Ω | $1\% + \frac{20}{1/\alpha^\circ + \frac{2}{}}$ | | $2\% + \frac{20}{2/\alpha^\circ + \frac{2}{}}$ |

Table 1-1. Specifications (Sheet 12 of 14)

Table C-2. |Z| - θ Accuracies

| Impedance Range | Test Frequency Range | | |
|-----------------|---|---|---|
| | 101Hz to 995Hz* | 1.01kHz to 9.95kHz | 10.1kHz to 20kHz |
| 10MΩ | $(1 + \alpha)\% + \frac{2}{(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ | $2(1 + \alpha)\% + \frac{2}{2(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ | $5(1 + \alpha)\% + \frac{2}{5(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ |
| 1MΩ | $.5(1 + \alpha)\% + \frac{2}{.5(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ | $(1 + \alpha)\% + \frac{2}{(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ | $2.5(1 + \alpha)\% + \frac{2}{2.5(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ |
| 100kΩ | | | |
| 10kΩ | $.2(1 + \alpha)\% + \frac{2}{.2(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ | $.4(1 + \alpha)\% + \frac{2}{.4(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ | $(1 + \alpha)\% + \frac{2}{(1 + \alpha)^\circ} + \frac{2}{\underline{2}}$ |
| 1kΩ | | | |
| 100Ω | $.1\% + \frac{5}{.1/\alpha^\circ} + \frac{5}{\underline{5}}$ | $.2\% + \frac{5}{.2/\alpha^\circ} + \frac{5}{\underline{5}}$ | $.5\% + \frac{5}{.5/\alpha^\circ} + \frac{5}{\underline{5}}$ |
| 10Ω | $.3\% + \frac{5}{.3/\alpha^\circ} + \frac{5}{\underline{5}}$ | $.6\% + \frac{5}{.6/\alpha^\circ} + \frac{5}{\underline{5}}$ | $1.5\% + \frac{5}{1.5/\alpha^\circ} + \frac{5}{\underline{5}}$ |
| 1Ω | $.7\% + \frac{2}{.5/\alpha^\circ} + \frac{2}{\underline{2}}$ | $1.4\% + \frac{2}{1/\alpha^\circ} + \frac{2}{\underline{2}}$ | $3.5\% + \frac{2}{2.5/\alpha^\circ} + \frac{2}{\underline{2}}$ |
| 100mΩ | $1\% + \frac{20}{1/\alpha^\circ} + \frac{20}{\underline{2}}$ | $2\% + \frac{20}{2/\alpha^\circ} + \frac{20}{\underline{2}}$ | $5\% + \frac{20}{5/\alpha^\circ} + \frac{20}{\underline{2}}$ |

* Except 120Hz

Equations in Tables C-1 and C-2 represent:

| |
|------------|
| Z Accuracy |
| θ Accuracy |

α: Full-scale factor (= measured |Z| value ÷ full-scale |Z| value). For example, when measured |Z| value is 850Ω on the 1000Ω range, α is 0.85.

Note 1: Tables C-1 and C-2 are available under the following conditions:

- (1) Test Signal Level: HIGH
- (2) Measurement Speed Mode: MED or SLOW
- (3) Sample's D Value: ≤ 0.1
- (4) Zero offset adjustment has been performed with the OPEN and SHORT terminations of the Model 16074A.

Note 2: When FAST measurement speed is used, accuracies double on the ranges outside the area enclosed in the bold line in Tables C-1 and C-2.

Note 3: LOW test signal level cannot be used in |Z| measurement mode.

Table 1-1. Specifications (Sheet 13 of 14)

Options

Option 001:

Internal DC Bias. Equips the standard 4276A with a variable 0 to ±40V dc voltage source for biasing DUTs connected to the UNKNOWN terminals. Output voltage can be set from the front panel or via the HP-IB.

Bias Control Range and Accuracy:

| Voltage Range | Step | Temperature | Accuracy |
|-----------------|-------|---------------------------|---------------------------|
| 10.0 to 40.0V | 100mV | 23°C ± 5°C 0°C to 55°C | ±(.5%+35mV) ±(1%+70mV) |
| .00 to 9.99V | 10mV | 23°C ± 5°C 0°C to 55°C | ±(.3%+10mV) ±(1%+20mV) |
| -9.99 to -.01V | 10mV | 23°C ± 5°C 0°C to 55°C | ±(1%+10mV) ±(2%+20mV) |
| -40.0 to -10.0V | 100mV | 23°C ± 5°C 0°C to 55°C | ±(1%+35mV) ±(2%+70mV) |

Note

DC bias voltage is specified 2 minutes after the voltage is set.

Output Impedance: 1020Ω±10%

Bias Voltage Monitor:

Bias voltage across the DUT can be monitored at the EXT INPUT/INT MONITOR BNC connector on the rear panel. INT MONITOR output impedance is approximately 730Ω.

Output Characteristics:

| Range Resistor Value | Maximum Current |
|----------------------|-----------------|
| 100Ω | 1mA |
| 1kΩ | 0.5mA |
| 10kΩ | 50μA |
| 100kΩ | 5μA |

Note

Refer to Figure 3-16 for the range resistor value.

Note

Measurement accuracies are not guaranteed if output current exceeds the maximum current for each range resistor.

Option 002: COMPARATOR/HANDLER INTERFACE

Contents:

Model 16064A COMPARATOR/HANDLER INTERFACE (Includes the 16064-66502 Interface board assembly and 1251-0084 36-pin male Amphenol connector)

Comparator Function:

Compares measured values to 9 sets (Bins) of stored high/low limits. Displays LOW/IN/HIGH judgements and bin number.

Handler Interface Function: Outputs comparison results and handler control signals (TTL, open-collectors). Detects KEY LOCK and EXT TRIGGER signals sent from component handler.

Option 907: Front handle kit (Part No. 5061-0090)

Option 908: Rack flange kit (Part No. 5061-0078)

Option 909: Rack flange and handle kit (Part No. 5061-0084)

Option 910: Extra manual

Table 1-1. Specifications (Sheet 14 of 14)

| Accessories Supplied | General Specifications | | | | |
|--|--|-------------|-------------|-------------|---------------|
| <p>Test Fixture: 16047A Test Fixture. Includes three kinds of contact inserts</p> <p>Power Cord: HP Part No. 8120-1378</p> <p>Fuse: Part No. 2110-0007 (100V/120V) Part No. 2110-0360 (220V/240V)</p> <p>Protective Fuse: Part No. 2110-0011 (for dc bias input)</p> | <p>Operating Temperature: 0 °C to 55 °C</p> <p>Relative Humidity: 95% at 40 °C</p> <p>Storage Temperature: -40 °C to +70 °C</p> <p>Power Requirements: 90V to 132V, 198V to 250V. 48Hz to 66Hz.</p> <p>Power Consumption: 65VAmax with any option</p> <p>Dimensions: 425.5 (W) x 188 (H) x 430 (D) mm</p> <p>Weight: Approximately 8.5kg</p> | | | | |
| Accessories Available | | | | | |
| <p>HP-IB Cable:</p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%;">10833A (1m)</td> <td style="width: 50%;">10833C (4m)</td> </tr> <tr> <td>10833B (2m)</td> <td>10833D (0.5m)</td> </tr> </table> <p>Test Fixtures and Test Leads: Refer to Table 1-3.</p> | | 10833A (1m) | 10833C (4m) | 10833B (2m) | 10833D (0.5m) |
| 10833A (1m) | 10833C (4m) | | | | |
| 10833B (2m) | 10833D (0.5m) | | | | |

1-32. ACCESSORIES AVAILABLE

1-33. In addition to the furnished 16047A Test Fixture, seven special purpose test fixtures and test leads are available. Each is intended for a particular measurement or DUT type, and all were designed with careful consideration to accuracy, reliability, ease of use, and compatibility with other HP instruments. A brief description of each available accessory is given in Table 1-3.

Table 1-2. Supplemental Performance Characteristics (Sheet 1 of 2)

Supplemental Performance Characteristics

Measurement Accuracy:

Additional Error in 1m/2m Test Lead Usage:

Add the following errors to the measurement accuracies listed in Table 1-1 when a 1m or 2m long test lead is used.

| Measurement Function | Additional Error |
|----------------------|--|
| L, C, Z | M% of reading |
| D | P |
| θ | 60P° |
| G (C-G) | M% of reading + (G full-scale value) x α P |
| G (L-G) | M% of reading + (G full-scale value) x P/ α |

where, α is the full scale factor, and M and P are represented as follows:

$$M = K (.16 + .1\ell) \times (.3f^2 + f)/100$$

$$P = K (.16 + .1\ell) \times (.09f^2 + 1.6f)/1000$$

where, ℓ is the cable length in meters, f is test frequency in kHz, and K is the range resistor factor. See Figure 3-16.

| Range Resistor Value | K |
|----------------------|-----|
| 100k Ω | 10 |
| 10k Ω | 1 |
| 1k Ω | 0.1 |
| 100 Ω | 0 |

The above errors are applicable under the following conditions:

- (1) Test Cable: HP Model 16048A (1m long) or 16048D (2m long)

- (2) Residual Capacitance to Ground: <100pF at HIGH terminals and <50pF at LOW terminals

- (3) Sample's D Value: <0.1

- (4) Zero offset adjustment has been performed with the OPEN and SHORT terminations of the 16074A.

Additional Error of Test Fixture:

Add the following errors to the measurement accuracies listed in Table 1-1 when these test fixtures or test leads are used:

| Model | Additional Error |
|--|--------------------------------------|
| 16047A, 16047C, 16048A, 16048B, 16048D, 16065A | - |
| 16048C | C<5pF L<200nH R<10m Ω |
| 16034B | C<0.02pF L<30nH R<50m Ω |

Accuracies in D>0.1:

Multiply the measurement accuracies for C, L, or D listed in Table 1-1 by (1 + D²), where D is the sample's D value.

Ranging Time: Approximately 60ms

Test Signal Settling Time:

Approximately 270ms when the test frequency is changed.

Approximately 60ms when the test signal level is changed.

The same as the dc bias settling time when the dc bias voltage is changed.

Continuous Memory:
2 weeks at 23 °C

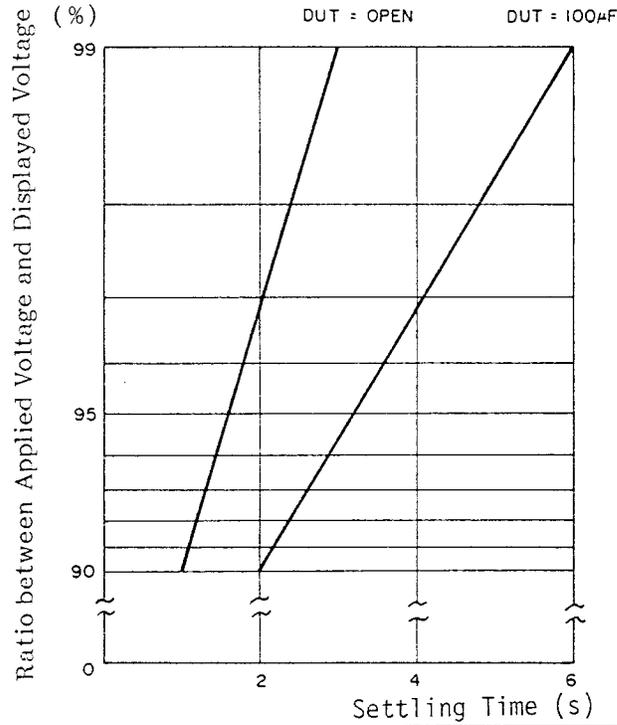
Table 1-2. Supplemental Performance Characteristics (Sheet 2 of 2)

DC Bias Settling Time:

Typical data for OPEN or a 100 μ F capacitor measurement.

Measurement Time:

See the table below:



| No. | Measurement Parameter | Measurement Speed Mode |
|-----|------------------------------|------------------------|
| ① | L, C | MED |
| ② | L, C | FAST |
| ③ | Z | MED |
| ④ | Z | FAST |
| ⑤ | HIGH SPEED L HIGH SPEED C | MED |
| ⑥ | HIGH SPEED L HIGH SPEED C | FAST |

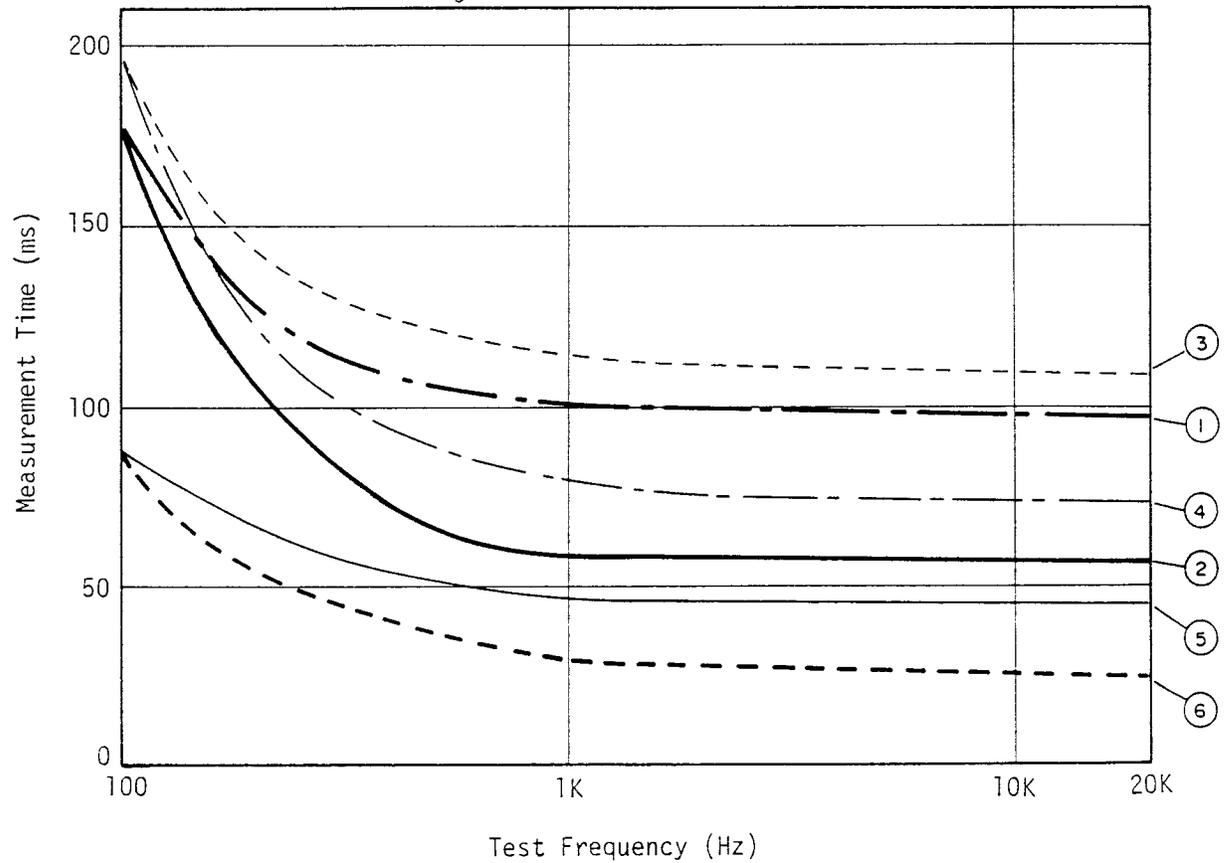


Table 1-3. Accessories Available (Sheet 1 of 3)

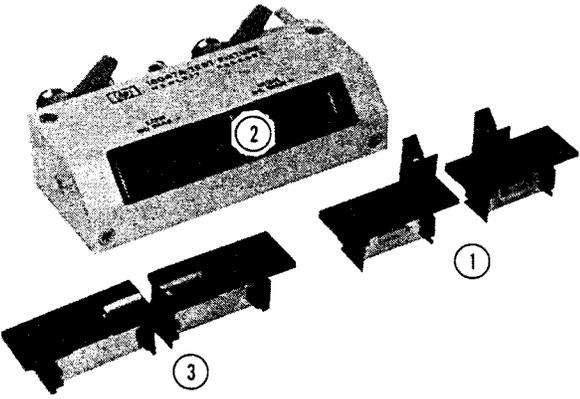
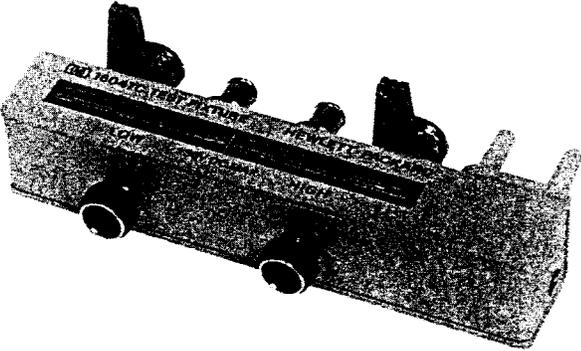
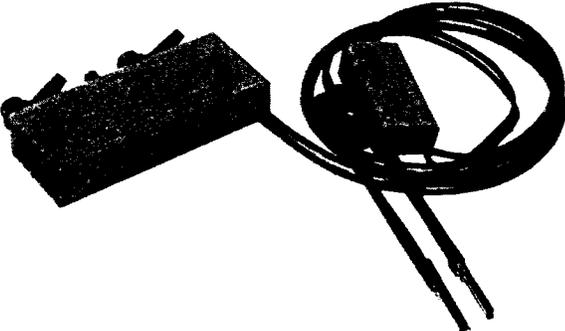
| Model | Description |
|--|--|
| <p>16047A</p>  | <p>Test Fixture (direct attachment type) for measurement of either axial-or radial-lead components. Three kinds of contact inserts are furnished:</p> <ul style="list-style-type: none"> ① For axial-lead components, (HP P/N: 16061-70022) ② For general radial-lead components, (HP P/N: 16061-70021) ③ For radial short-lead components, (HP P/N: 16047-65001) <p>DC bias up to $\pm 40V^*$ can be applied.</p> |
| <p>16047C</p>  | <p>Test Fixture (direct attachment type) designed especially for high frequency measurements requiring high accuracy. Two screw knobs facilitate and ensure optimum contact between the test fixture electrodes and the sample leads.</p> <p>DC bias up to $\pm 40V^*$ can be applied.</p> |
| <p>16034B</p>  | <p>Test Fixture (tweezer type) for measurement of miniature leadless components such as chip capacitors. Employs a three terminal configuration tweezer probe suitable for high impedance (above 50Ω) measurements.</p> <p>DC bias up to $\pm 40V^*$ can be applied.</p> <p>Cable length: 1m</p> |

Table 1-3. Accessories Available (Sheet 2 of 3)

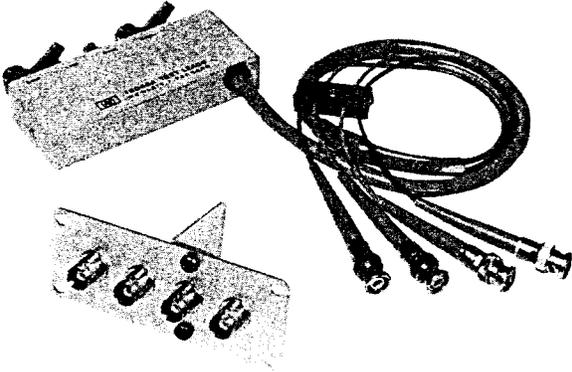
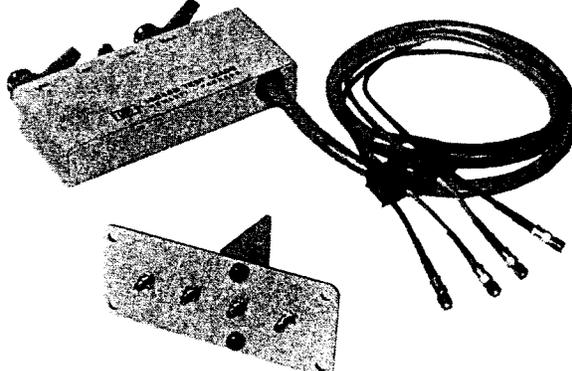
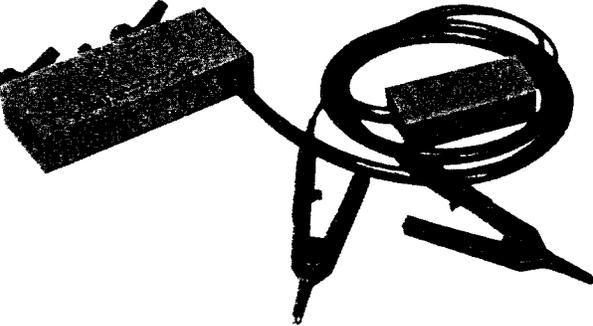
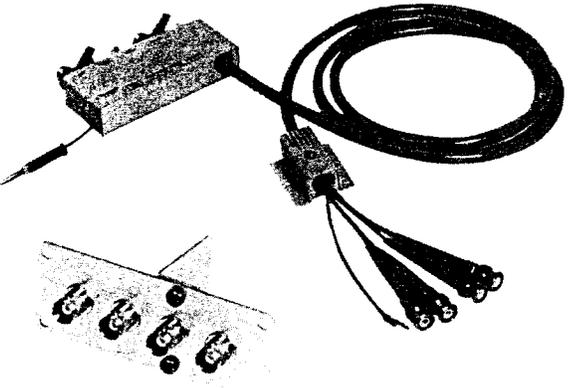
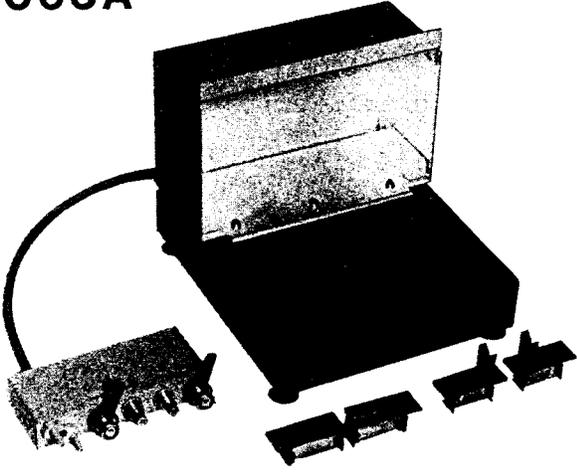
| Model | Description | | | | |
|--|--|-------------|--------|------------|-------------|
| <p>16048A</p>  | <p>Test Leads (four terminal pair) with BNC connectors for connecting user-fabricated test fixtures.</p> <p>DC bias up to $\pm 40V^*$ can be applied.</p> <p>Cable length: 1m</p> | | | | |
| <p>16048B</p>  | <p>Test Leads (four terminal pair) with miniature RF connectors suitable for connecting user-fabricated test fixtures in systems applications.</p> <p>DC bias up to $\pm 40V^*$ can be applied.</p> <p>Cable length: 1m</p> | | | | |
| <p>16048C</p>  | <p>Test Leads with dual alligator clips for testing components of non-standard shapes and sizes at frequencies below 100kHz.</p> <p>Applicable measurement ranges:</p> <table border="0"> <tr> <td>Capacitance</td> <td>1000pF</td> </tr> <tr> <td>Inductance</td> <td>100 μH</td> </tr> </table> <p>DC bias up to $\pm 40V^*$ can be applied.</p> <p>Cable length: 1m</p> | Capacitance | 1000pF | Inductance | 100 μH |
| Capacitance | 1000pF | | | | |
| Inductance | 100 μH | | | | |

Table 1-3. Accessories Available (Sheet 3 of 3)

| Model | Description |
|---|---|
| <p>16048D</p>  | <p>Double-shielded Test Leads (four terminal pair) with BNC connectors for connecting user-fabricated test fixtures.</p> <p>DC bias up to $\pm 40V^*$ can be applied.</p> <p>Cable length: 2m</p> |
| <p>16065A</p>  | <p>Test Fixture (cable connection type) for measurement of either axial- or radial-lead components at frequencies between 50Hz and 2MHz. Three kinds of contact inserts are furnished (same as those for the 16047A Test Fixture).</p> <p>DC bias up to $\pm 200V$ can be applied (a protective cover provides for operator safety).</p> <p>Cable length: Approximately 40cm</p> |
| <p>* Though "$\pm 35V$ DC MAX" is indicated on the test fixtures, they are capable of handling dc bias voltages up to $\pm 40V$ when used with the 4276A.</p> | |

SECTION II INSTALLATION

2-1. INTRODUCTION

2-2. This section provides installation instructions for the Model 4276A LCZ Meter. It also includes information on initial inspection and damage claims, preparation for using the 4276A, and packaging, storage, and shipment.

2-3. INITIAL INSPECTION

2-4. The 4276A LCZ Meter, as shipped from the factory, meets all the specifications listed in Table 1-1. Upon receipt, inspect the shipping container for damage. If the shipping container or cushioning material is damaged, it should be kept until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically. The contents of the shipment should be as shown in Figure 1-1. The procedures for checking the general electrical operation are given in Section III (Paragraph 3-5 SELF TEST) and the procedures for checking the 4276A LCZ Meter against its specifications are given in Section IV. First, do the self test. If the 4276A is electrically questionable, then do the Performance Tests to determine whether the 4276A has failed or not.

If the contents are incomplete, if there is mechanical damage or defects (scratches, dents, broken switches, etc.), or if the performance does not meet the self test or performance tests, notify the nearest Hewlett-Packard office (see list at back of this manual). The HP office will arrange for repair or replacement without waiting for claim settlement.

2-5. PREPARATION FOR USE

2-6. POWER REQUIREMENTS

2-7. The 4276A requires a power source of 100, 120, 220 Volts ac $\pm 10\%$, or 240 Volts ac $+5\%-10\%$, 48 to 66Hz single phase; power consumption is 65VA maximum.

WARNING

IF THE INSTRUMENT IS TO BE ENERGIZED VIA AN EXTERNAL AUTOTRANSFORMER UNIT FOR VOLTAGE REDUCTION, BE SURE THAT THE COMMON TERMINAL IS CONNECTED TO THE NEUTRAL POLE OF THE POWER SUPPLY.

2-8. LINE VOLTAGE AND FUSE SELECTION

CAUTION

BEFORE TURNING THE 4276A LINE SWITCH TO ON, VERIFY THAT THE INSTRUMENT IS SET TO THE VOLTAGE OF THE POWER TO BE SUPPLIED.

2-9. Figure 2-1 provides instructions for line voltage and fuse selection. The line voltage selection switch and the proper fuse are factory installed for the voltage appropriate to instrument destination.

CAUTION

USE PROPER FUSE FOR LINE VOLTAGE SELECTED.

CAUTION

MAKE SURE THAT ONLY FUSES FOR THE REQUIRED RATED CURRENT AND OF THE SPECIFIED TYPE ARE USED FOR REPLACEMENT. THE USE OF MENDED FUSES AND THE SHORT-CIRCUITING OF FUSE-HOLDERS MUST BE AVOIDED.

2-10. POWER CABLE

2-11. To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that the instrument panel and cabinet be grounded. The Model 4276A is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The offset pin on the power cable is the ground wire.

2-12. To preserve the protection feature when operating the instrument from a two contact outlet, use a three prong to two prong adapter (HP Part No. 1251-0048) and connect the green pigtail on the adapter to power line ground.

CAUTION

THE MAINS PLUG MUST ONLY BE INSERTED IN A SOCKET OUTLET PROVIDED WITH A PROTECTIVE EARTH CONTACT. THE PROTECTIVE ACTION MUST NOT BE NEGATED BY THE USE OF AN EXTENSION CORD (POWER CABLE) WITHOUT PROTECTIVE CONDUCTOR (GROUNDING).

2-13. Figure 2-2 shows the available power cords, which may be used in various countries including the standard power cord furnished with the instrument. HP Part number, applicable standards for power plug, power cord color, electrical characteristics and countries using each power cord are listed in the figure. If assistance is needed for selecting the correct power cable, contact the nearest Hewlett-Packard office.

2-14. INTERCONNECTIONS

2-15. When an external dc bias source is used, set the DC BIAS select switch on the rear panel to EXT. The output from the external bias source should be connected to EXT INPUT/INT MONITOR connector. The external dc bias fuse is installed in EXT DC BIAS FUSE Holder on rear panel to protect the instrument from excessive current. Fuse rating is as follows:

1/16A, 250V (HP Part No: 2110-0011)

CAUTION

MAKE SURE THAT ONLY FUSES OF THE REQUIRED RATED CURRENT AND OF THE SPECIFIED TYPE ARE USED FOR REPLACEMENT. THE USE OF MENDED FUSES AND THE SHORT-CIRCUITING OF FUSE-HOLDERS MUST BE AVOIDED.

2-16. OPERATING ENVIRONMENT

2-17. Temperature. The instrument may be operated in temperatures from 0 °C to +55 °C.

2-18. Humidity. The instrument may be operated in environments with relative humidities to 95% at 40 °C. However, the instrument must be protected from temperature extremes which cause condensation within the instrument.

2-19. INSTALLATION INSTRUCTIONS

2-20. The HP Model 4276A can be operated on the bench or in a rack mount. The 4276A is ready for bench operation as shipped from the factory. For bench operation a two-leg instrument stand is used. For use, the instrument stands are designed to be pulled towards the front of instrument.

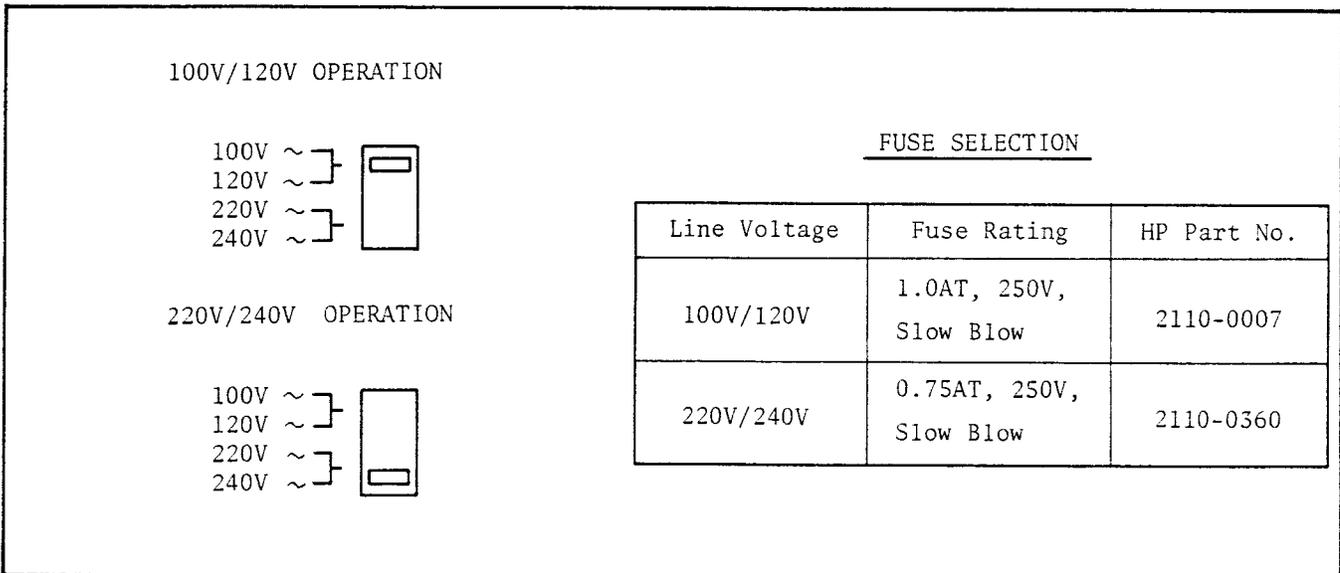


Figure 2-1. Voltage and Fuse Selection.

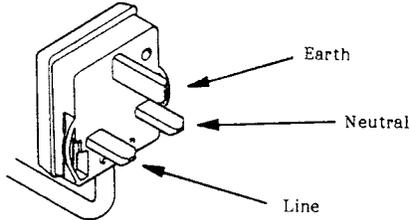
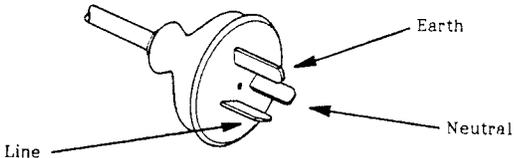
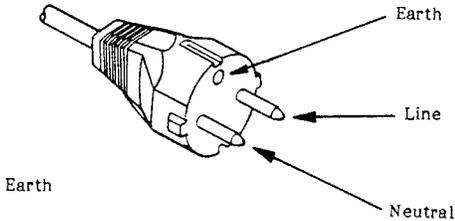
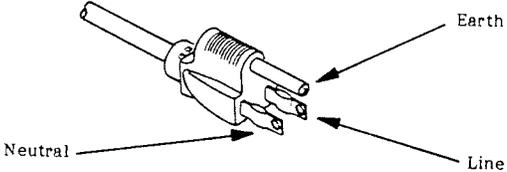
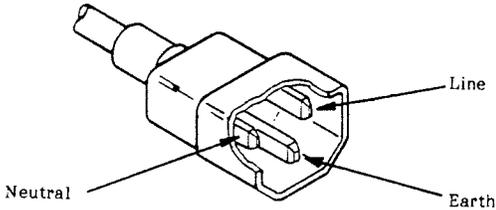
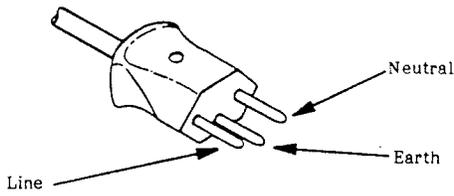
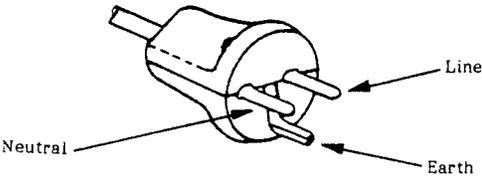
| | |
|---|--|
| <p>OPTION 900 United Kingdom</p>  <p>Plug : BS 1363A, 250V Cable : HP 8120-1351</p> | <p>OPTION 901 Australia/New Zealand</p>  <p>Plug : NZSS 198/AS C112, 250V Cable : HP 8120-1369</p> |
| <p>OPTION 902 European Continent</p>  <p>Plug : CEE-VII, 250V Cable : HP 8120-1689</p> | <p>OPTION 903 U.S./Canada</p>  <p>Plug : NEMA 5-15P, 125V, 15A Cable : HP 8120-1378</p> |
| <p>OPTION 905* Any country</p>  <p>Plug : CEE 22-VI, 250V Cable : HP 8120-1396</p> | <p>OPTION 906 Switzerland</p>  <p>Plug : SEV 1011.1959-24507 Type 12, 250V Cable : HP 8120-2104</p> |
| <p>OPTION 912 Denmark</p>  <p>Plug : DHCR 107, 220V Cable : HP 8120-2956</p> | <p>* Plug option 905 is frequently used for interconnecting system components and peripherals.</p> <p>NOTE: Each option number includes a 'family' of cords and connectors of various materials and plug body configurations (straight, 90 ° etc.)</p> |

Figure 2-2. Power Cables Supplied.

SECTION II

2-21. Installation of Options 907, 908 and 909.

2-22. The 4276A can be installed in a rack and be operated as a component of a measurement system. Rack mounting information for the 4276A is presented in Figure 2-3.

2-23. STORAGE AND SHIPMENT

2-24. ENVIRONMENT

2-25. The instrument may be stored or shipped in environments within the following limits:

Temperature -40 °C to +70 °C
Humidity to 95% at 40 °C

The instrument must be protected from temperature extremes which cause condensation inside the instrument.

2-26. PACKAGING

2-27. Original Packaging. Containers and materials identical to those used in factory packaging are available from Hewlett-Packard. If the instrument is being returned to Hewlett-Packard for servicing, attach a tag indicating the type of service required, return address, model number, and full serial number. Also mark the container FRAGILE to assure careful handling. In any correspondence, refer to the instrument by model number and full serial number.

2-28. Other Packaging. The following general instructions should be used for re-packing with commercially available materials:

- a. Wrap instrument in heavy paper or plastic. If shipping to Hewlett-Packard office or service center, attach tag indicating type of service required, return address, model number, and full serial number.
- b. Use strong shipping container. A double-wall carton made of 350 pound test material is adequate.
- c. Use enough shock absorbing material (3 to 4 inch layer) around all sides of instrument to provide firm cushion and prevent movement inside container. Protect control panel with cardboard.
- d. Seal shipping container securely.
- e. Mark shipping container FRAGILE to ensure careful handling.

- f. In any correspondence, refer to instrument by model number and full serial number.

2-29. OPTION INSTALLATION

2-30. Installation procedures for DC Bias option (Option 001) and Comparator/Handler Interface option (Option 002) are given in Figure 2-4.

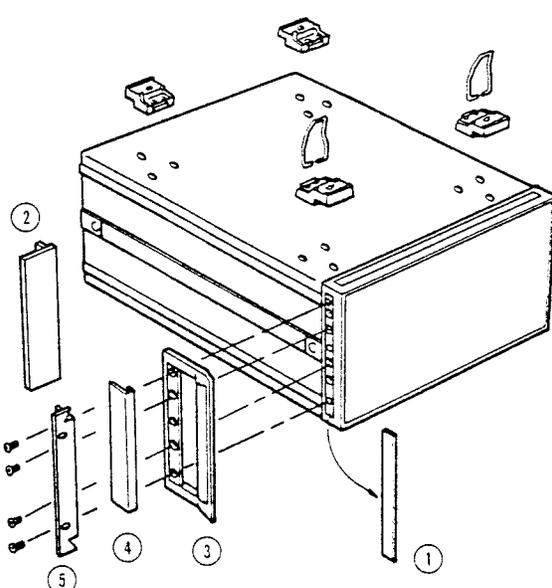
2-31. POWER FAILURE MONITOR INSTALLATION

2-32. To use the power failure monitor signal, you must solder two wires to a jumper on the mother board, remove a cap from a hole on the rear panel, and bring the wires out through the hole. The procedure is given below. A simplified drawing of the open collector circuit, a timing diagram, and the locations of the jumper and hole are shown in Figure 2-6. Refer to paragraph 3-114 for a description of the power failure monitor signal.

Procedure :

1. Turn off the 4276A.
2. Disconnect the 4276A from the ac power source.
3. Remove the top cover.
4. Disconnect the brown 4-terminal connector from the A5 board.
5. Remove the two screws that secure the A5 board to the chassis.
6. Remove the A5 board.
7. Solder a wire to each terminal of A6J3. The location of A6J3 is shown in Figure 2-6 (c).
8. Remove the cap from the access hole in the rear panel, as shown in Figure 2-6 (d).
9. Thread the wires first through the teflon clamp (securing the wires from A6J1) on the A6 board, and then through the access hole in the rear panel.
10. Reinstall the A5 board, reconnect the brown 4-terminal connector to the A5 board, and replace the top cover.

| Option | Kit Part Number | Parts Included | Part Number | Q'ty | Remarks |
|--------|---------------------------------------|--|---|-------------|----------|
| 907 | Handle Kit 5061-0090 | Front Handle Trim Strip X8-32 x 3/8 Screw | ③ 5060-9900 ④ 5020-8897 2510-0195 | 2 2 8 | 9.525mm |
| 908 | Rack Flange Kit 5061-0078 | Rack Mount Flange X8-32 x 3/8 Screw | ② 5020-8863 2510-0193 | 2 8 | 9.525mm |
| 909 | Rack Flange & Handle Kit 5061-0084 | Front handle Rack Mount Flange X8-32 x 3/8 Screw | ③ 5060-9900 ⑤ 5020-8875 2510-0194 | 2 2 8 | 15.875mm |



1. Remove adhesive-backed trim strips ① from side at right and left front of instrument.
2. HANDLE INSTALLATION : Attach front handle ③ to sides at right and left front of instrument with screws provided and attach trim ④ to handle.
3. RACK MOUNTING : Attach rack mount flange ② to sides at right and left front of instrument with screws provided.
4. HANDLE AND RACK MOUNTING : Attach front handle ③ and rack mount flange ⑤ together to sides at right and left front of instrument with screws provided.
5. When rack mounting (3 and 4 above), remove all four feet (lift bar at inner side of foot, and slide foot toward the bar).

Figure 2-3. Rack Mount Kit.

11. Connect the pull-up resistor and external voltage source as shown in Figure 2-6 (a).

Note

A +5V is recommended but higher voltage can be used as long as the current through AlT5 and AlQ4 does not exceed 25mA.

CAUTION: BEFORE PROCEEDING WITH INSTALLATION OF OPTION(S), TURN OFF THE INSTRUMENT AND DISCONNECT THE AC POWER CORD.

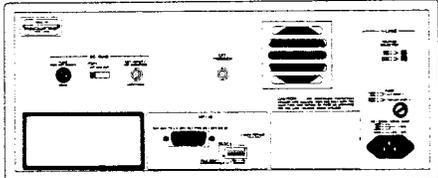
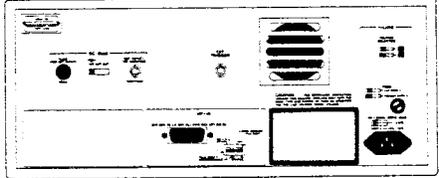
| | OPTION 001 DC BIAS SUPPLY (0 to $\pm 40V$) | OPTION 002 COMPARATOR/ HANDLER INTERFACE |
|--|---|---|
| Option Parts | Board Assembly A22 04276-66522 | Comparator 16064A Includes: Interface Board Assembly 16064-66502 and 36-pin male Amphenol connector 1251-0084 |
| Installation Procedure (after removing top cover) | <ol style="list-style-type: none"> 1. Remove the rear panel access plate shown below.  <ol style="list-style-type: none"> 2. Insert the dc bias board (P/N: 04276-66522) into the access hole. 3. Insert the male edge connector of the interface board into the female edge connector of the 4276A mother board and push firmly until the interface board is completely seated. 4. Reinstall the screws removed in step (1). | <ol style="list-style-type: none"> 1. Remove the rear panel access plate shown below.  <ol style="list-style-type: none"> 2. Insert the interface board (P/N: 16064-66502) into the access hole. 3. Insert the male edge connector of the interface board into the female edge connector of the 4276A mother board and push firmly until the interface board is completely seated. 4. Reinstall the screws removed in step 1. 5. Connect the 16064A keyboard cable to the connector on the interface board (installed in step 3). 6. Adjust the power supply in accordance with the procedure given in Figure 2-5. |

Figure 2-4. Option Installation.

1. Connect the 4276A to the ac power line.
2. Turn on the instrument. ("16064" should be displayed on DISPLAY B.)
3. Connect A DVM (HP 3478A is recommended) to A1TP1 and GND as shown below.
4. Adjust "V-ADJ" on the A4 board until the reading on the DVM is $5.10V \pm 0.02V$.

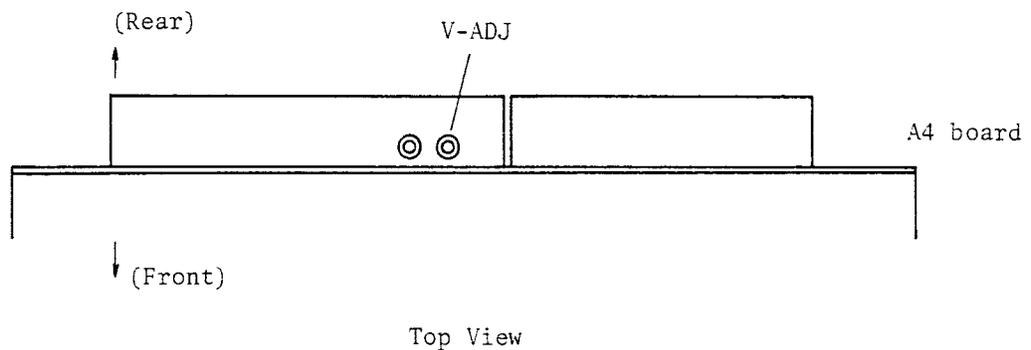
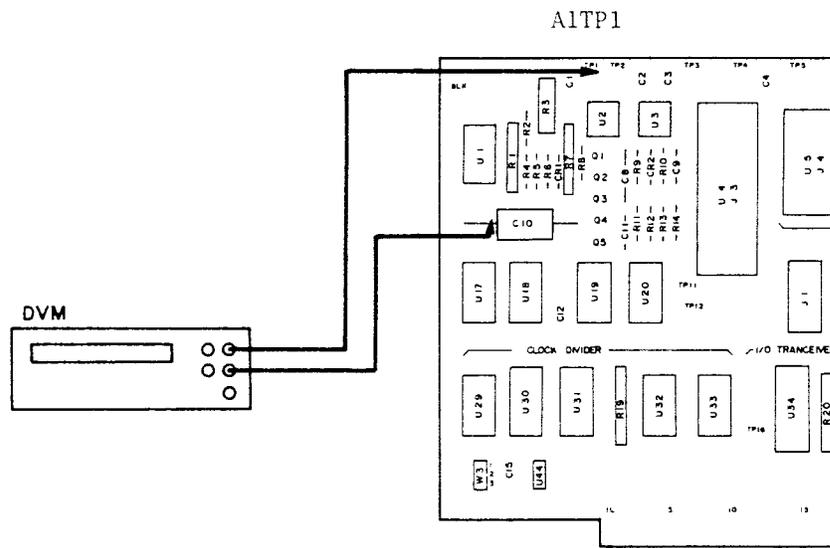


Figure 2-5. Power Supply Adjustment After Installing Option 002.

SECTION II

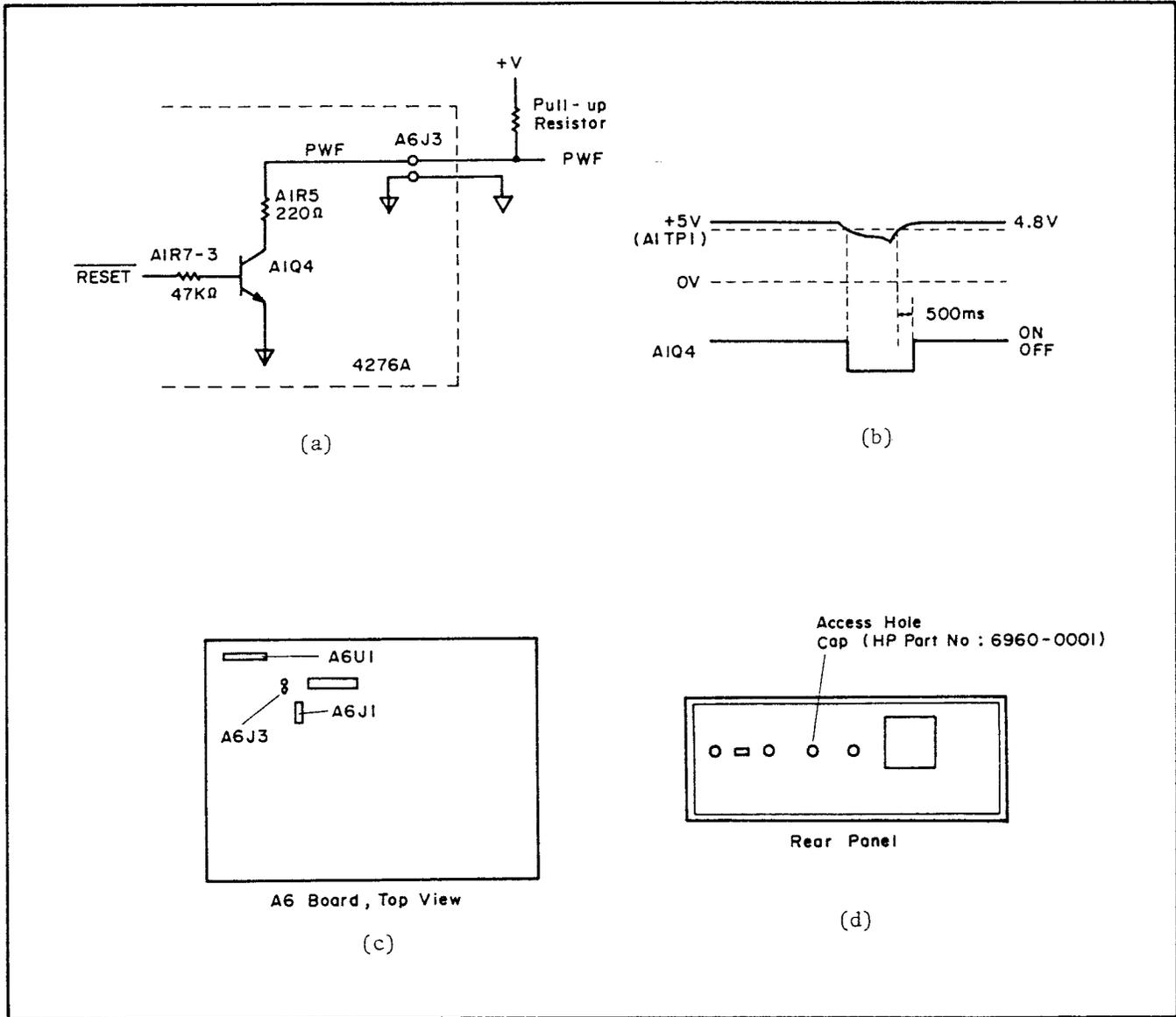


Figure 2-6. Power Failure Monitor Installation.

SECTION III OPERATION

3-1. INTRODUCTION

3-2. This section provides all the information necessary to operate the Model 4276A LCZ Meter. Included are descriptions of the front- and rear-panels, displays, lamps and connectors; discussions on operating procedures and measuring techniques for various applications; and instructions on the instrument's SELF TEST function. Warnings, Cautions, and Notes are given throughout; they should be observed to insure the safety of the operator and the serviceability of the instrument.

WARNING

BEFORE THE INSTRUMENT IS SWITCHED ON, ALL PROTECTIVE EARTH TERMINALS, EXTENSION CORDS, AUTO-TRANSFORMERS AND DEVICES CONNECTED TO IT SHOULD BE CONNECTED TO A PROTECTIVE EARTH GROUNDED SOCKET. ANY INTERRUPTION OF THE PROTECTIVE EARTH GROUNDING WILL CAUSE A POTENTIAL SHOCK HAZARD THAT COULD RESULT IN SERIOUS PERSONAL INJURY.

ONLY FUSES WITH THE REQUIRED RATED CURRENT AND OF THE SPECIFIED TYPE SHOULD BE USED. DO NOT USE REPAIRED FUSES OR SHORTED FUSEHOLDERS. TO DO SO COULD CAUSE A SHOCK OR FIRE HAZARD.

CAUTION

BEFORE THE INSTRUMENT IS SWITCHED ON, IT MUST BE SET TO THE VOLTAGE OF THE POWER SOURCE (MAINS), OR DAMAGE TO THE INSTRUMENT MAY RESULT.

3-3. PANEL FEATURES

3-4. Figures 3-1 and 3-2 identify and briefly describe the purpose of each key, indicator, and connector on the front panel and rear panel, respectively. More detailed information on front panel displays and controls is given starting in paragraph 3-5.

3-5. SELF TEST

3-6. The self test function confirms correct operation of the instrument's basic functions and facilitates troubleshooting. It consists of three parts: (1) ROM/RAM Test, (2) Display Test, and (3) Analog Circuit Test. Each is described in paragraphs 3-7 through 3-11.

3-7. ROM/RAM Test

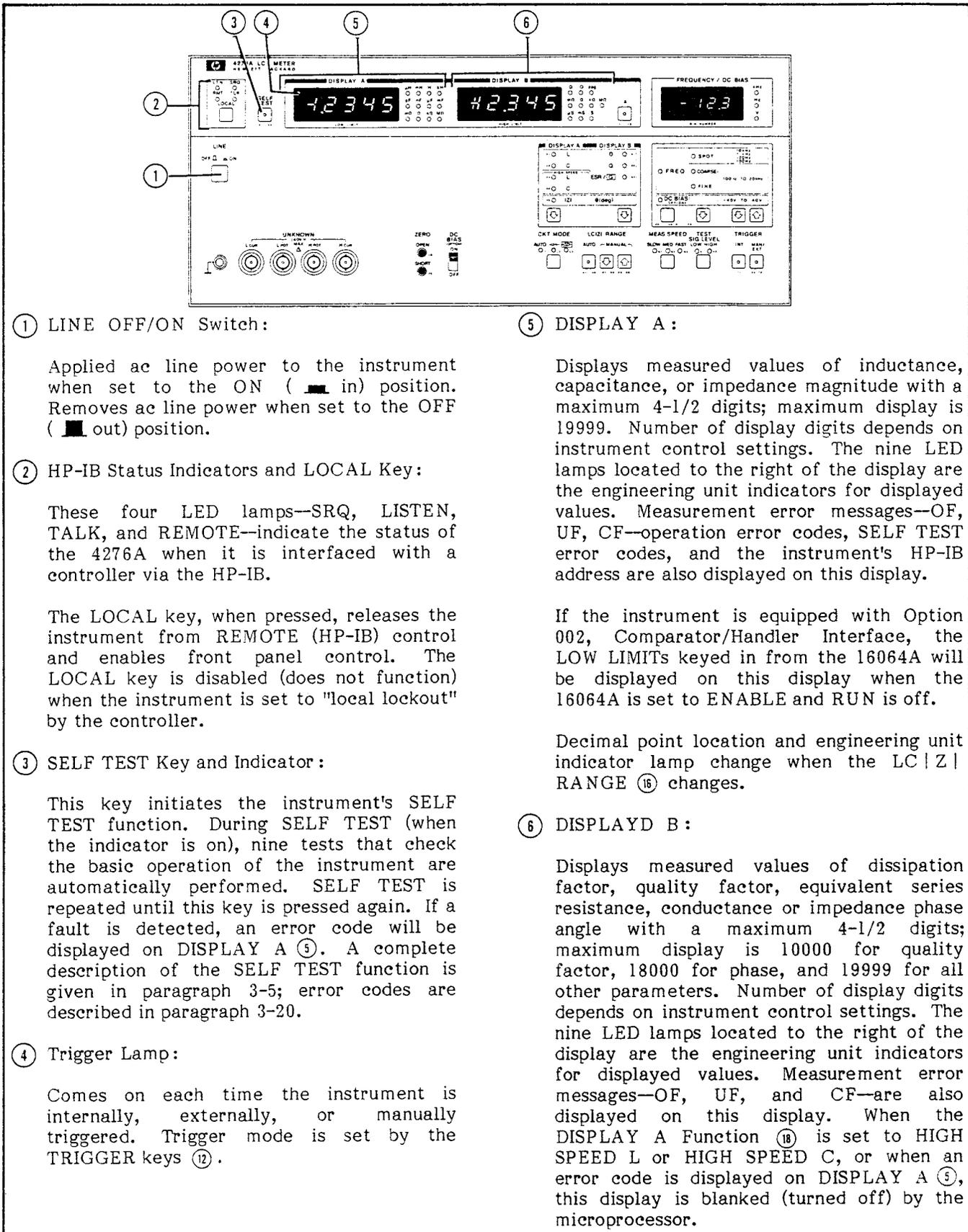
3-8. The ROM/RAM Test is performed each time the instrument is turned on. During this test, all ROMs and RAMs in the instrument's digital control section are tested using a check-sum test and a read/write test (RAMs only). If a malfunction is detected, the test will stop and an error-code will be displayed on DISPLAY A. If the ROMs and RAMs are functioning properly, the instrument will display the HP-IB address (or output data format if the HP-IB control switch is set to TALK ONLY) on DISPLAY A and the option annunciations on DISPLAY B and the FREQUENCY/DC BIAS DISPLAY. Error-codes are described in paragraph 3-20.

Note

If a ROM/RAM test error code, E61 through E68, appears on DISPLAY A when the instrument is turned on, contact the nearest Hewlett-Packard Sales or Service Office for repairs.

Note

ROM/RAM test error code E68 indicates that the instrument's continuous memory feature is not functioning properly. All other instrument functions, including measurement, are not affected.



① LINE OFF/ON Switch:

Applied ac line power to the instrument when set to the ON (in) position. Removes ac line power when set to the OFF (out) position.

② HP-IB Status Indicators and LOCAL Key:

These four LED lamps—SRQ, LISTEN, TALK, and REMOTE—indicate the status of the 4276A when it is interfaced with a controller via the HP-IB.

The LOCAL key, when pressed, releases the instrument from REMOTE (HP-IB) control and enables front panel control. The LOCAL key is disabled (does not function) when the instrument is set to "local lockout" by the controller.

③ SELF TEST Key and Indicator:

This key initiates the instrument's SELF TEST function. During SELF TEST (when the indicator is on), nine tests that check the basic operation of the instrument are automatically performed. SELF TEST is repeated until this key is pressed again. If a fault is detected, an error code will be displayed on DISPLAY A ⑤. A complete description of the SELF TEST function is given in paragraph 3-5; error codes are described in paragraph 3-20.

④ Trigger Lamp:

Comes on each time the instrument is internally, externally, or manually triggered. Trigger mode is set by the TRIGGER keys ⑫.

⑤ DISPLAY A:

Displays measured values of inductance, capacitance, or impedance magnitude with a maximum 4-1/2 digits; maximum display is 19999. Number of display digits depends on instrument control settings. The nine LED lamps located to the right of the display are the engineering unit indicators for displayed values. Measurement error messages—OF, UF, CF—operation error codes, SELF TEST error codes, and the instrument's HP-IB address are also displayed on this display.

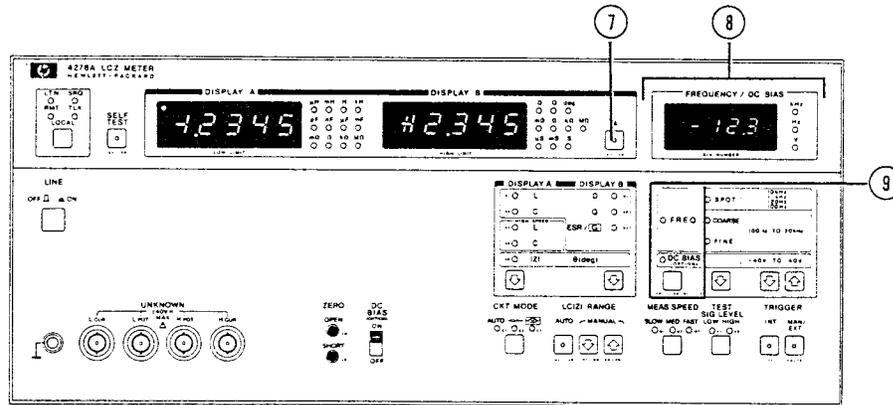
If the instrument is equipped with Option 002, Comparator/Handler Interface, the LOW LIMITs keyed in from the 16064A will be displayed on this display when the 16064A is set to ENABLE and RUN is off.

Decimal point location and engineering unit indicator lamp change when the LC|Z|RANGE ⑬ changes.

⑥ DISPLAY B:

Displays measured values of dissipation factor, quality factor, equivalent series resistance, conductance or impedance phase angle with a maximum 4-1/2 digits; maximum display is 10000 for quality factor, 18000 for phase, and 19999 for all other parameters. Number of display digits depends on instrument control settings. The nine LED lamps located to the right of the display are the engineering unit indicators for displayed values. Measurement error messages—OF, UF, and CF—are also displayed on this display. When the DISPLAY A Function ⑩ is set to HIGH SPEED L or HIGH SPEED C, or when an error code is displayed on DISPLAY A ⑤, this display is blanked (turned off) by the microprocessor.

Figure 3-1. Front Panel Features (Sheet 1 of 6).



If the instrument is equipped with Option 002, Comparator/Handler Interface, and if the 16064A comparator is connected, the number 16064 will be displayed on this display when the instrument is turned on. Also, the HIGH LIMITs keyed in from the 16064A will be displayed on this display when the 16064A is set to ENABLE and RUN is off.

⑦ Δ Key and Indicator :

This key enables deviation (Δ) measurements on both displays. When this key is pressed, the values displayed on DISPLAY A ⑤ and DISPLAY B ⑥ are stored as reference values. The difference between values obtained in subsequent measurements and the stored reference values is calculated and displayed on each display. The formula used to calculate the deviation is

$$A-B$$

Where A is the measured value of the device under test and B is the stored reference value.

LC|Z| RANGE ⑮ is set to MANUAL when this key is pressed.

Also, the deviation measurement function is turned off by pressing this key again, or by changing the DISPLAY A function ⑱, DISPLAY B function ⑲, LC|Z| RANGE ⑮, or CIRCUIT MODE ⑳. It may be turned off also if the test frequency is changed when the DISPLAY B function is ESR/G.

⑧ FREQUENCY/DC BIAS Display :

Displays test frequency or DC bias voltage (Option 001 only) with 3 digits. The three LED lamps located to the right of the display are unit indicators for displayed values. On instruments equipped with Option 002, Comparator/Handler Interface, bin numbers are displayed on this display when the comparator is set to RUN. Also, on Option 001 instruments, the number 001 is briefly displayed here when the instrument is turned on.

⑨ FREQUENCY/DC BIAS Select Key and Indicators :

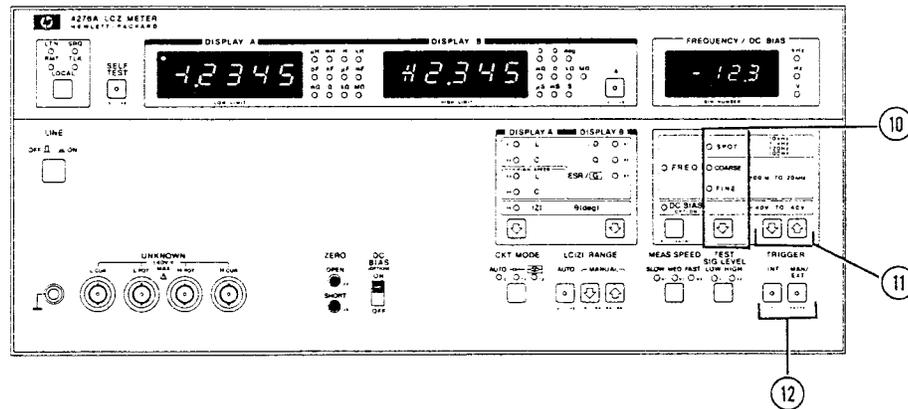
This key sets the FREQUENCY/DC BIAS Display ⑧, the SPOT/COARSE/FINE Select key ⑩, and the FREQUENCY/DC BIAS Step Control Keys ⑪ to FREQUENCY control mode or DC BIAS control mode. The selected control mode is indicated by the corresponding LED lamp.

FREQ: When this LED lamp is on, frequency is displayed on the FREQUENCY/DC BIAS Display and is controlled by the SPOT/COARSE/FINE Key and the FREQUENCY/DC BIAS Step Control Keys.

DC BIAS: When this LED lamp is on, DC bias voltage is displayed on the FREQUENCY/DC BIAS Display and is controlled by the FREQUENCY/DC BIAS Step Control Keys.

FREQUENCY control mode and DC BIAS control mode are mutually exclusive, and DC BIAS can be selected only if the instrument is equipped with Option 001.

Figure 3-1. Front Panel Features (Sheet 2 of 6).



⑩ SPOT/COARSE/FINE Select Key and Indicators:

This key selects the SPOT, COARSE, or FINE vernier mode for frequency changes mode by the FREQUENCY/DC BIAS Step Control Keys ⑪. The selected vernier mode is indicated by the corresponding LED lamp. Frequencies possible in each vernier mode are listed below

SPOT: 100Hz, 120Hz, 1kHz, 10kHz

COARSE: 100Hz to 1kHz in 100Hz steps
1kHz to 10kHz in 1kHz steps
10kHz to 20kHz in 10kHz steps

FINE: 100Hz to 200Hz in 1Hz steps
200Hz to 500Hz in 2Hz steps
500Hz to 1kHz in 5Hz steps
1kHz to 2kHz in 10Hz steps
2kHz to 5kHz in 20Hz steps
5kHz to 10kHz in 50Hz steps
10kHz to 20kHz in 100Hz steps

Note

When the FREQUENCY/DC BIAS Select Key ⑨ is set to DC BIAS mode, this key is disabled and the SPOT, COARSE, and FINE indicators are turned off.

⑪ FREQUENCY/DC BIAS Step Control Keys:

These keys-- \square and \square —are used in conjunction with the FREQUENCY/DC BIAS Select Key ⑨ and the SPOT/COARSE/FINE Select Key ⑩ to set the test frequency and DC bias voltage (Option 001 instruments only). When

FREQUENCY mode is selected by the FREQUENCY/DC BIAS Select Key ⑨, test frequency is increased in accordance with the selected vernier mode (SPOT, COARSE, FINE) each time the \square is pressed, and is decreased each time the \square key is pressed. These keys control DC bias in a similar manner when DC BIAS mode is selected by the FREQUENCY/DC BIAS Select Key ⑨. When either of these keys is pressed and held, the value displayed on the FREQUENCY/DC BIAS Display will continuously change in the indicated direction. The actual value, however, will not change until the key is released.

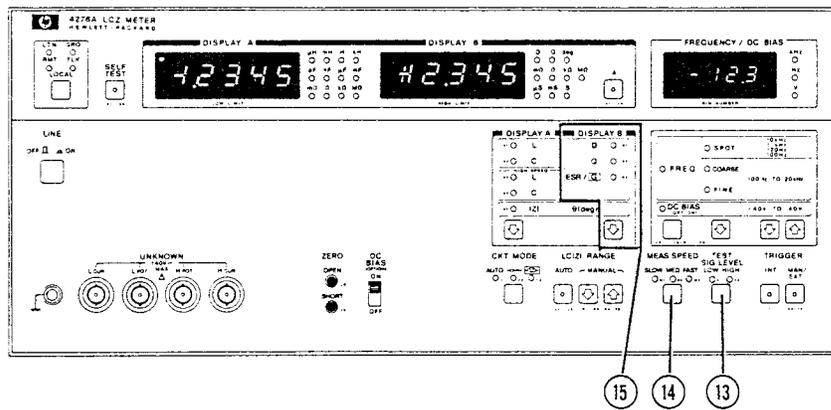
⑫ TRIGGER Keys:

These keys select the trigger mode for triggering measurement (Internal or Manual/External):

INT: Internal trigger signal enables instrument to make repeated automatic measurements.

MAN/EXT: Measurement is triggered each time this key is pressed. Measurement data is held until the next time the key is pressed. Or in this mode measurement is triggered by an external trigger signal applied to the rear panel EXT TRIGGER connector (④ in Figure 3-2).

Figure 3-1. Front Panel Features (Sheet 3 of 6).



⑬ TEST SIGNAL LEVEL Selector Key and Indicators:

This key selects two test signal levels : HIGH and LOW. HIGH level is 1Vrms and LOW level is 50mVrms. The selected test signal level is indicated by the corresponding LED lamp.

Note

The 4276A cannot measure L, HIGH SPEED L, or Z when TEST SIGNAL LEVEL is set to LOW.

⑭ MEASUREMENT SPEED Select Key and Indicators:

This key selects three measurement speeds: SLOW, MEDIUM or FAST. Actual measurement speed depends on test frequency, LC|Z| range ⑮, DISPLAY A Function ⑯, and the value of the device under test. The selected measurement speed mode is indicated by the corresponding LED lamp.

SLOW: Measurement speed is approximately 1/4 that of medium measurement speed.

MED: Measurement speed is approximately 11 measurements per second in C-G measurement mode.

FAST: Measurement speed is approximately twice that of medium measurement speed.

⑮ DISPLAY B Function Select Key and Indicators:

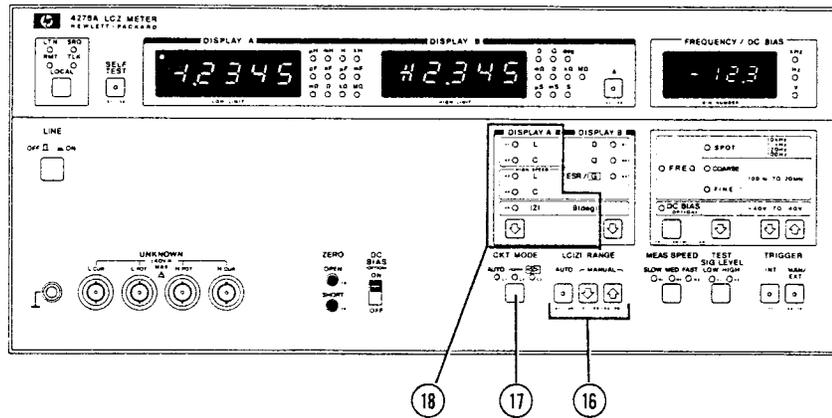
This key, , selects the measurement parameter for display on DISPLAY B ⑥. The selected parameter is indicated by the corresponding LED lamp. Pressing this key shifts the selected parameter in a top-to-bottom sequence. Selectable parameters are as follows:

D: Measures the dissipation factor of the DUT. DISPLAY A Function ⑯ must be set to L (inductance) or C (capacitance).

Q: Measures the quality factor of the DUT. DISPLAY A Function ⑯ must be set to L (inductance) or C (capacitance). Q values are calculated as the reciprocal dissipation factor.

ESR/G: Measures the equivalent series resistance or conductance of the DUT. DISPLAY A Function ⑯ must be set to L (inductance) or C (capacitance). ESR is selected when CIRCUIT MODE ⑰ is set to ; G is selected when CIRCUIT MODE ⑰ is set to .

Figure 3-1. Front Panel Features (Sheet 4 of 6).



16 LC|Z| RANGE Selector Keys and Indicator:

These keys select the measurement range and the ranging method for inductance, capacitance and impedance measurements.

AUTO (when indicator is lit):

Optimum range for the DUT's value is automatically selected.

MANUAL (when indicator is not lit):

Measurement range is fixed (even when the DUT is changed). Manual ranging is done by pressing the adjacent DOWN (⏮) or UP (⏭) key.

Note

Pressing the DOWN or UP key sets the ranging mode to MANUAL even if the ranging mode was initially set to AUTO.

17 CIRCUIT MODE Select Key and Indicators:

This key selects the measurement circuit mode to be used during measurement. The selected circuit mode is indicated by the corresponding LED lamp.

AUTO: Automatically selects the equivalent circuit (parallel or series) most appropriate for the DUT's value. When LC|Z| RANGE 16 is set to the 100Ω range or lower, circuit mode is set to . When LC|Z| RANGE 16 is set to the 1kΩ range or higher, circuit mode is set to .

: Selects equivalent series circuit.

: Selects equivalent parallel circuit.

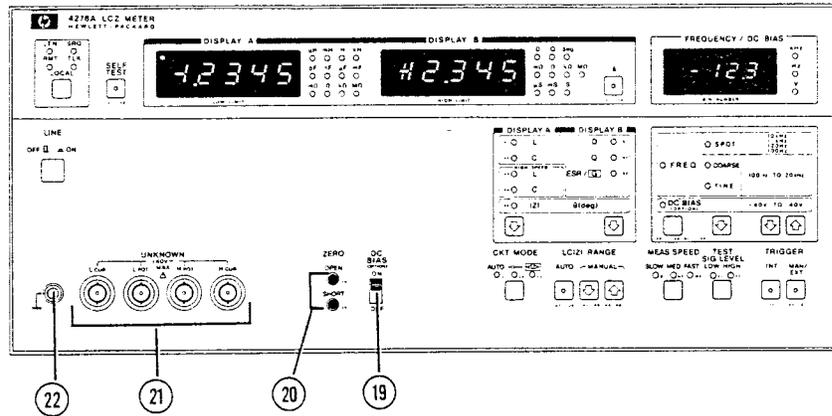
18 DISPLAY A Function Select Key and Indicators:

This key, , selects the measurement parameter for display on DISPLAY A 5. The selected parameter is indicated by the corresponding LED lamp. Pressing this key shifts the selected parameter in a top-to-bottom sequence. The selectable parameters are as follows:

L: Measures inductance and—depending on the setting of DISPLAY B Function 15—D (dissipation factor), Q (quality factor), or ESR/G (equivalent series resistance or equivalent parallel conductance).

C: Measures capacitance and—depending on the setting of DISPLAY B Function 15—D (Dissipation factor), Q (quality factor), or ESR/G (equivalent series resistance or equivalent parallel conductance).

Figure 3-1. Front Panel Features (Sheet 5 of 6).



HIGH SPEED L :
Measures only inductance.

HIGH SPEED C :
Measures only capacitance.

$|Z| - \theta$ (deg) :
Measures impedance magnitude and phase angle. The results are displayed on DISPLAY A ($|Z|$) and DISPLAY B (θ) to provide a polar representation ($|Z| \angle \theta$) of the DUT's impedance.

19 DC BIAS SWITCH :

On instruments equipped with Option 001, DC BIAS, this switch turns the internal DC bias source on and off. When this switch is set to ON and the DC BIAS Select Switch (2) in Figure 3-2) on the rear panel is set to INT, the DC voltage selected by the FREQUENCY/DC BIAS Step Control Keys (1) is output from the H_{CUR} UNKNOWN terminal (21). When set to OFF, this switch turns off the internal DC bias source; no DC voltage is output from the H_{CUR} UNKNOWN terminal (21), and "OFF" will be briefly displayed on the FREQUENCY/DC BIAS Display 8 each time a new DC bias voltage is set by the FREQUENCY/DC BIAS Step Control Keys 11 or via the HP-IB.

Note

This switch controls the internal DC bias source only. It does not control external DC bias voltage applied to the EXT INPUT/INT MONITOR connector (3) in Figure 3-2) on the rear panel. Also, this switch is not HP-IB programmable.

20 ZERO Offset :

These buttons perform ZERO offset compensation (OPEN and SHORT) for the residuals of the test fixture, test leads, and measurement circuit. ZERO offset is performed at the following spot frequencies:

- 20kHz, 16kHz, 10kHz, 5kHz, 2kHz, 1kHz, 500Hz, 200Hz, and 100Hz.

OPEN : If this button is pressed when the test fixture or test leads are terminated open, measured values at this time are stored as residual admittance data.

SHORT : If this button is pressed when the test fixture or test leads are shorted, measured values at this time are stored as residual impedance data.

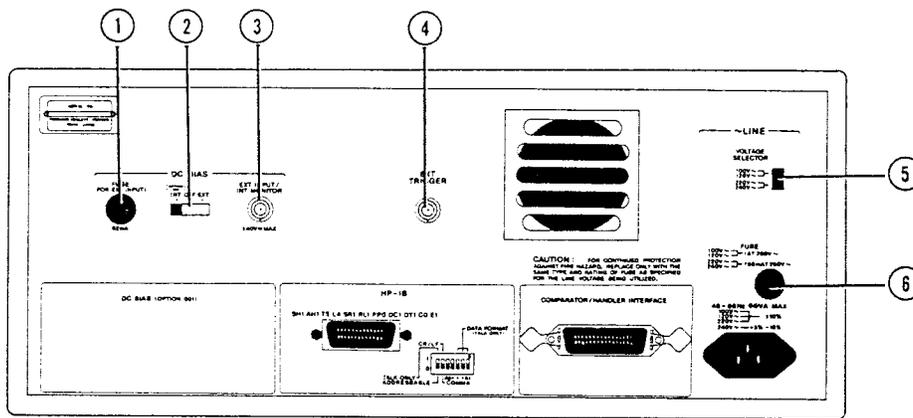
21 UNKNOWN Terminals :

These four BNC connectors provide the means to connect DUT's in a five-terminal configuration: High current terminal (H_{CUR}), High potential terminal (H_{POT}), Low potential terminal (L_{POT}), and Low current terminal (L_{CUR}). Four-terminal pair test fixtures attach directly to these terminals.

22 GUARD Terminal :

This terminal is tied to the instrument's chassis and can be used in measurements that require guarding.

Figure 3-1. Front Panel Features (Sheet 6 of 6).



① EXT DC BIAS FUSE Holder :

External DC bias fuse is installed in this holder. The fuse must be installed when an external bias source is used. Fuse rating is 1/16A, 250V (HP P/N: 2110-0011).

② DC BIAS Select Switch :

This switch selects the DC bias source that will be used for biasing DUTs connected to the UNKNOWN terminals.

INT: On instruments equipped with Option 001, DC BIAS, the DC voltage output from the internal DC bias source will be applied to the DUT when the DC BIAS Switch (②) in Figure 3-2) is set to ON.

OFF: No DC bias voltage will be applied to the DUT.

EXT: DC voltage provided by an external voltage source connected to the EXT INPUT/INT MONITOR Connector (③) will be applied to the DUT regardless of the setting of the DC BIAS Switch (② in Figure 3-2). Maximum allowable voltage is $\pm 40V$.

③ EXT INPUT/INT MONITOR Connector :

The function of this connector depends on the setting of the DC BIAS Select Switch (②). When the DC BIAS Select Switch (②) is set to EXT, this connector is the input terminal for an external DC voltage source. When the DC BIAS Select Switch (②) is set to INT, this connector is the monitor output terminal for the internal DC bias source (Option 001 instruments only).

④ EXT TRIGGER Connector :

This connector is for external trigger input. TRIGGER key on front panel should be set to MAN/EXT. Specific information is provided in paragraph 3-70.

⑤ ~LINE VOLTAGE SELECTOR Switch :

This switch selects the appropriate ac operating voltage. Selectable voltages are 100V/120V $\pm 10\%$ and 220V $\pm 10\%$ /240V $\pm 5\%$ -10% (48 - 66Hz).

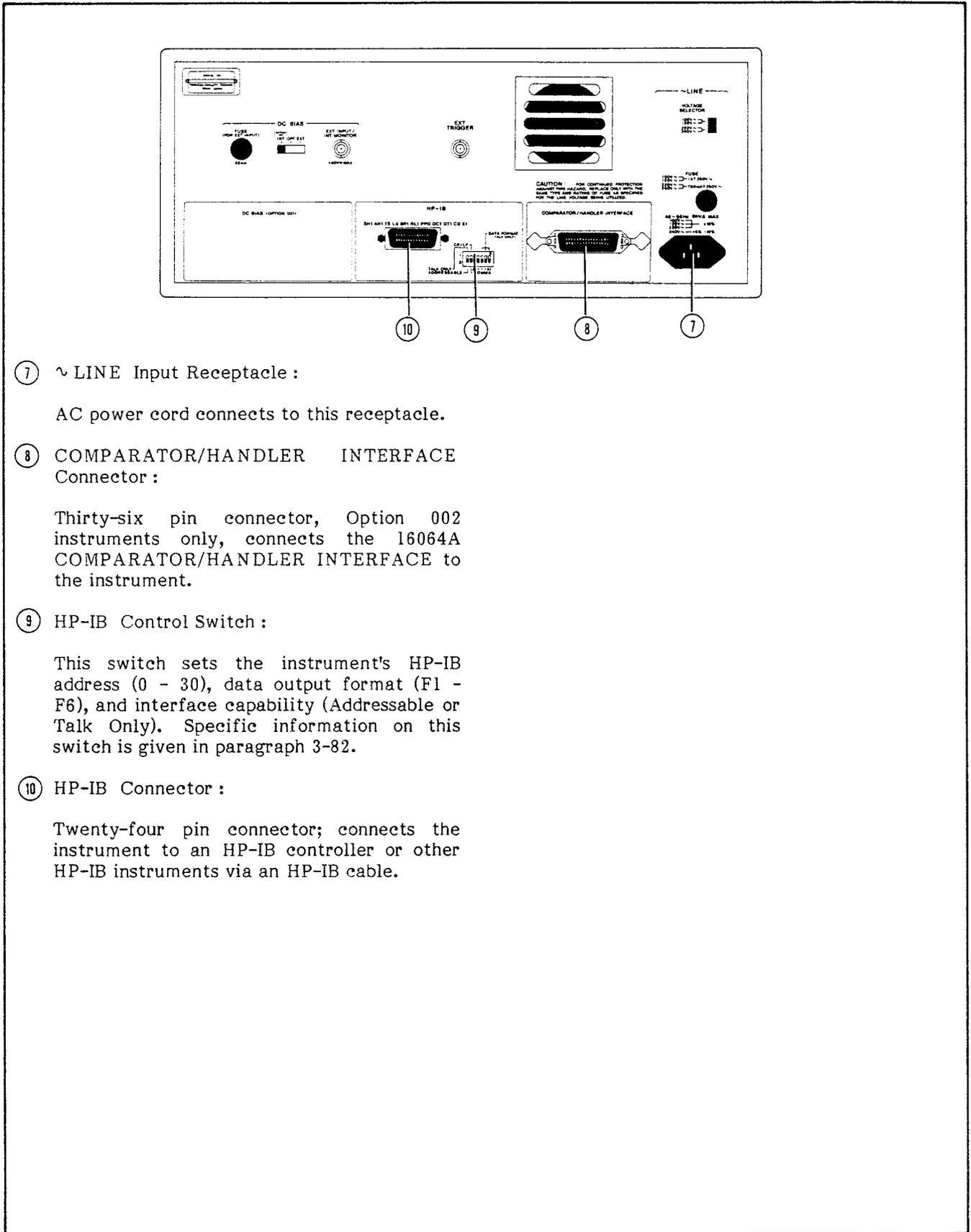
⑥ ~LINE FUSE Holder :

Instrument's power-line fuse is installed in this holder.

100V/120V operation :
1AT, 250V
(HP P/N : 2110-0007)

220V/240V operation :
750mAT, 250V
(HP P/N : 2110-0360)

Figure 3-2. Rear Panel Features (Sheet 1 of 2).



⑦ ~LINE Input Receptacle :

AC power cord connects to this receptacle.

⑧ COMPARATOR/HANDLER INTERFACE Connector :

Thirty-six pin connector, Option 002 instruments only, connects the 16064A COMPARATOR/HANDLER INTERFACE to the instrument.

⑨ HP-IB Control Switch :

This switch sets the instrument's HP-IB address (0 - 30), data output format (F1 - F6), and interface capability (Addressable or Talk Only). Specific information on this switch is given in paragraph 3-82.

⑩ HP-IB Connector :

Twenty-four pin connector; connects the instrument to an HP-IB controller or other HP-IB instruments via an HP-IB cable.

Figure 3-2. Rear Panel Features (Sheet 2 of 2).

SECTION III

3-9. DISPLAY TEST

3-10. All LED lamps and 7-segment displays on the front panel are lit for approximately one second when the instrument's self-test function is initiated from the front panel or via the HP-IB. This test is repeated until the self-test function is turned off.

Note

If an LED lamp or 7-segment display fails to light during the Display test, contact the nearest Hewlett-Packard Sales or Service Office for repairs.

Note

If the instrument is equipped with Option 002, Comparator/Handler Interface, and if the 16064A Comparator/Handler Interface is connected to the instrument, all 16064A LED lamps except D/Q/ESR/G and LIMIT LOW lamps will be lit during the Display test.

3-11. ANALOG CIRCUIT TEST

3-12. The Analog Circuit test is performed when the instrument's self-test function is initiated from the front panel or via the HP-IB. It is performed after the Display test, described in paragraph 3-9, and it confirms correct operation of the instruments analog circuits. Like the Display test, this test is repeated until the self-test function is turned off. The test lasts approximately three seconds. If a malfunction is detected, an error-code will be displayed on DISPLAY A. Refer to Table 3-4.

Note

The Analog Circuit test must be performed with an open-terminated (no DUT) test fixture (e.g., 16047A) connected to the UNKNOWN terminals.

Note

If one or more of the error codes listed in Table 3-4 appear on DISPLAY A during the Analog Circuit test, contact the nearest Hewlett-Packard Sales or Service Office for repairs.

3-13. MEASUREMENT FUNCTIONS

3-14. Values displayed on DISPLAY A and DISPLAY B are for the parameters selected by the DISPLAY A and DISPLAY B function keys.

Inductance (L), capacitance (C), or impedance magnitude ($|Z|$) values are displayed on DISPLAY A; dissipation factor (D), quality factor (Q), equivalent series resistance (ESR), conductance (G), or impedance phase (θ) values are displayed on DISPLAY B. The DISPLAY B measurement function depends on the selected DISPLAY A function and the selected CKT MODE, as listed in Table 3-1. When DISPLAY A function is HIGH SPEED C or HIGH SPEED L, DISPLAY B is always blank.

Table 3-1. Measurement Functions

| DISPLAY A | DISPLAY B | |
|--------------|---|---|
| | Circuit Mode | |
| |  |  |
| L | D, Q, or ESR | D, Q, or G |
| C | D, Q, or ESR | D, Q, or G |
| HIGH SPEED L | _____ | _____ |
| HIGH SPEED C | _____ | _____ |
| $ Z $ | θ | θ |

3-15. DISPLAYS

3-16. The 4276A has three front panel displays: DISPLAY A, DISPLAY B, and FREQUENCY/DC BIAS. Each is described in paragraphs 3-17 through 3-19, respectively. The number of display digits depends on measurement range, test frequency, and test signal level. Refer to Figure 3-39.

3-17. DISPLAY A provides direct readout of measured C, L, or $|Z|$, with 4 1/2-digit display resolution. The actual number of display digits depends on measurement range, test frequency, and test signal level. The least significant digit may be displayed as a small zero, , or may be blank, , to indicate that the digit does not provide a specified value. Maximum number of counts is ± 19999 . DISPLAY A also displays error-codes, operational annunciations, and the HP-IB address or output data format (refer to paragraphs 3-72 through 104 for details).

3-18. DISPLAY B provides direct readout of measured D, Q, ESR, G, or θ , with 4 1/2-digit display resolution. The actual number of display digits depends on measurement range, test frequency, test signal level, and number of DISPLAY A counts. The least significant digit may be displayed as a small zero, \square , or may be blank, \blacksquare , to indicate that the digit does not provide a specified value. Maximum number of display counts depends on the DISPLAY B function. Refer to Table 3-2. DISPLAY B also displays error-codes, operational annunciations, and option annunciation "16064" when the instrument is equipped with option 002. When the DISPLAY A function is HIGH SPEED C or HIGH SPEED L, DISPLAY B is blank.

Note

Option annunciation "16064" appears only when the 16064A Comparator is connected to the rear panel.

Table 3-2. Number of Counts on DISPLAY B

| Measurement Function | Display Counts |
|----------------------|---|
| D | Max. 1.9999 |
| Q | Max. 10 \square \square \square \square |
| ESR/G | - 19999 to 19999 counts |
| θ | - 180.00° to 180.00° |

3-19. The FREQUENCY/DC BIAS display provides direct readout of test frequency and, if the instrument is equipped with option 001, the voltage output from the internal dc bias source. If option 001 is installed, option annunciation 001 is displayed on this display each time the instrument is turned on. If the DC BIAS ON/OFF switch is set to OFF when the dc bias voltage is changed, OFF will be briefly displayed on this display after the new value has been set. Refer to paragraph 3-24. Also, if the instrument is equipped with option 002, BIN numbers are displayed on this display when the 16064A Comparator is enabled.

3-20. ERROR-CODES

3-21. Error-codes related to the ROM/RAM test (see paragraph 3-7) are listed in Table 3-3. If one of these errors is displayed on DISPLAY A when the instrument is turned on, measurements can not be made.

Note

If E68 is displayed, measurements can be made. The instrument's continuous memory function, however, is disabled.

3-22. Error-codes related to the Analog Circuit test (see paragraph 3-11) are listed in Table 3-4. If one or more of these errors are displayed on DISPLAY A during Self Test, the specifications listed in Table 1-1 are not guaranteed.

Note

If one of the error-codes listed in Table 3-3 or Table 3-4 is displayed, contact the nearest Hewlett-Packard Sales or Service Office for repairs.

3-23. Error-codes related to operator errors are listed in Table 3-5. Corrective action for each error is also given in the table.

3-24. OPERATIONAL ANNUNCIATION

3-25. On instruments equipped with option 001, DC BIAS, the annunciation shown in Table 3-6 may briefly appear on the FREQUENCY/DC BIAS display after a new dc bias voltage has been set. It indicates that the DC BIAS ON/OFF switch on the front panel is set to OFF. This switch must be set to ON if voltage from the internal dc bias source is to be applied to the DUT.

Note

For applications using the internal dc bias source, the DC BIAS select switch on the rear panel must be set to INT.

Table 3-3. Error-Codes for ROM/RAM Self Test

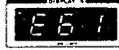
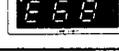
| Error Code | Meaning |
|---|-------------------------------|
|  | A1U5 ROM is faulty. |
|  | A1U6 ROM is faulty. |
|  | A1U7 ROM is faulty. |
|  | A1U8 ROM is faulty. |
|  | A1U9 ROM is faulty. |
|  | A1U10 ROM is faulty. |
|  | A1U12 RAM is faulty. |
|  | A1U12 RAM or A6BT1 is faulty. |

Table 3-4. Error-Codes for Analog Circuit Self Test

| Display | Meaning |
|---|---|
|  | Analog Circuit is not functioning properly. |

Table 3-6. Operation Error Codes Displayed on FREQUENCY/DC BIAS Display

| DISPLAY A | DISPLAY B | FREQ/DC BIAS | Meanings | Treatment |
|--|--|---|---|---|
|  (any reading) |  (any reading) |  | Illegal INTERNAL DC BIAS operation (Option 001). The internal dc bias voltage was set manually or via the HP-IB when the DC BIAS ON/OFF switch on the front panel was set to OFF. | Set the DC BIAS switch to ON. Note Make sure that the DC BIAS switch on the rear panel is set to INT. |

Table 3-5. Operation Error Codes Displayed on DISPLAY A/B (Sheet 1 of 3)

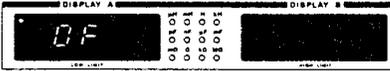
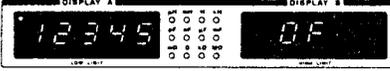
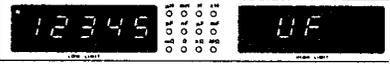
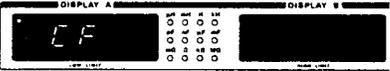
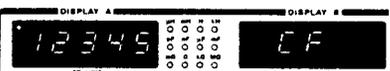
| ERROR CODE | Meaning | Treatment |
|--|---|--|
|  | Overflow - The inductance, capacitance, or impedance of the DUT is too high to be measured on the selected LC Z RANGE. | Select a higher LC Z RANGE. |
|  <p>(any reading)</p> | Overflow - The dissipation factor, quality factor, ESR, or conductance of the DUT is too high. | Change the DISPLAY B function, or change the DISPLAY A function to Z . |
|  | Underflow -The inductance, capacitance, or impedance of the DUT is too low to be measured on the selected LC Z RANGE. | Select a lower LC Z RANGE. |
|  <p>(any reading)</p> | Underflow -The dissipation factor, quality factor, ESR, or conductance of the DUT is too low. | Change the DISPLAY B function, or change the DISPLAY A function to Z . |
|  | Change Function -The selected parameter cannot be measured with the present control settings. | Change the DISPLAY A function to another parameter. |
|  <p>(any reading)</p> | | Change the DISPLAY B function, or change the DISPLAY A function to Z . |
|  | Zero Offset Adjustment error. The residuals of the test fixture or test leads are too high to be offset, or nothing is connected to the UNKNOWN terminals. Previous Zero Offset data are unchanged. | Use a different test fixture or test leads; or, if nothing is connected to the UNKNOWN terminals, connect an appropriate test fixture or test leads. Refer to paragraph 3-48 for details on Zero Offset Adjustments. |

Table 3-5. Operation Error Codes Displayed on DISPLAY A/B (Sheet 2 of 3)

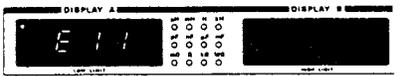
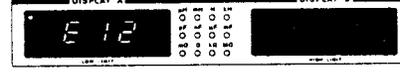
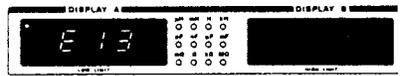
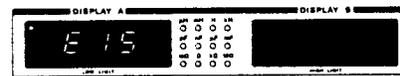
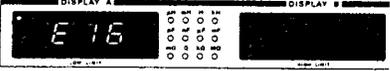
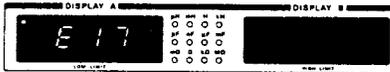
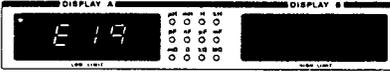
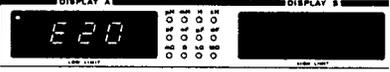
| ERROR CODE | Meaning | Treatment |
|---|---|---|
|  | TEST SIG LEVEL was set to LOW when DISPLAY A function is set to L, HIGH SPEED L, or Z . | LOW TEST SIG LEVEL can be used only for C and HIGH SPEED C measurements. |
|  | Illegal LC Z RANGE, DISPLAY A, FREQ, or TEST SIG LEVEL setting. | The instrument will automatically select the correct setting. |
|  | Illegal DC BIAS or COMPARATOR operation. Internal dc bias voltage was set via the HP-IB, but the instrument is not equipped with Option 001; or the comparator enable code (E1) was sent via the HP-IB; but the instrument is not equipped with Option 002. | Install the desired option. Refer to Section II. |
|  | Illegal COMPARATOR operation. The D/Q/ESR/G key on the 16064A was pressed or was set via the HP-IB while the DISPLAY A function was set to HIGH SPEED C, HIGH SPEED L, or Z . | D, Q, ESR, or G comparison cannot be performed. The instrument is set to HIGH SPEED L or HIGH SPEED C measurement mode. |
|  | Illegal COMPARATOR operation. One of the 4276A's front panel keys (except TRIGGER, LOCAL, or DC BIAS) was pressed or was set via the HP-IB. | To change a front panel setting on the 4276A, first disable (turn off) the 16064A. Press the COMPARATOR ENABLE key (the lamp at the center of the key should go off). |
| | Illegal COMPARATOR operation. One of the 16064A's keys (except the COMPARATOR ENABLE key) was pressed or was set via HP-IB while the 16064A was disabled. | To operate the COMPARATOR, first enable (turn on) the 16064A. Press the COMPARATOR ENABLE key (the lamp at the center of the key should come on). |

Table 3-5. Operation Error Codes Displayed on DISPLAY A/B (Sheet 3 of 3)

| ERROR CODE | Meaning | Treatment |
|---|--|--|
|  | <p>Illegal COMPARATOR operation. The 4276A's front panel control settings are different from those that existed when the present bin limits were entered.</p> | <p>Reset the front panel controls to the previous settings, or clear the stored bin limits by pressing the ERASE button.</p> |
|  | <p>Illegal COMPARATOR operation. The RUN key on the 16064A was pressed or was set via HP-IB when no bin limits were entered, or a bin's LOW LIMIT is higher than its HIGH LIMIT.</p> | <p>Enter LOW and HIGH limits, or correct the displayed LOW and HIGH LIMITS.</p> |
|  | <p>Illegal parameter setting. The test frequency setting, internal dc bias setting, or a bin limit setting is outside the specified limits.</p> | <p>Reset the incorrect parameter.</p> |
|  | <p>Illegal HP-IB address. The HP-IB address switches on the rear panel were set to 31 (11111) when the instrument was turned on.</p> | <p>Turn off the instrument and set the HP-IB address to one between 0 (00000) and 30 (11110).</p> |
|  | <p>Illegal deviation measurement operation. The Δ key on the front panel was pressed or was set via HP-IB when DF, UF, or CF was displayed on DISPLAY A or DISPLAY B.</p> | <p>Only valid reference values can be used for deviation measurement.</p> |

SECTION III

3-26. TEST FREQUENCY

3-27. There are seven test frequency ranges, as listed in Table 3-7. Frequency accuracy is 0.01% of the value displayed on the FREQUENCY/DC BIAS display.

Table 3-7. Test Frequency

| Test Frequency | Resolution |
|-------------------|------------|
| 100Hz - 200Hz | 1Hz |
| 200Hz - 500Hz | 2Hz |
| 500kHz - 1.00kHz | 5Hz |
| 1.00kHz - 2.00kHz | 10Hz |
| 2.00kHz - 5.00kHz | 20Hz |
| 5.00kHz - 10.0kHz | 50Hz |
| 10.0kHz - 20.0kHz | 100Hz |

3-28. TEST SIGNAL LEVEL

3-29. The 4276A has two test signal levels: HIGH (1Vrms) and LOW (50mVrms). The output impedance of the test signal source is $100\Omega \pm 20\%$, so the voltage across the DUT depends on the DUT's impedance. Refer to Figure 3-3.

Note

On several ranges, HIGH test signal level is 2Vrms. Refer to Table 1-1.

Note

Low test signal level can be used only when DISPLAY A function is set to C or HIGH SPEED C.

3-30. MEASUREMENT RANGE

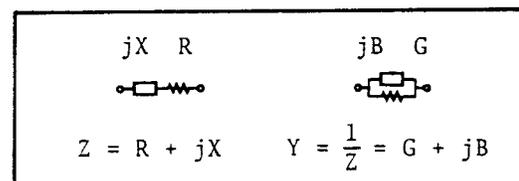
3-31. Measurement range depends on the test frequency. The ranges which can be selected at each test frequency and the range resistor used on each range are shown in Figure 3-16. Each range allows a 100% overrange of the 10000 full scale counts (maximum 19999 counts).

Measurement range is selected by the LC|Z|RANGE keys. When the LC|Z|RANGE control is set to AUTO, the optimum range is automatically selected for each measurement. Manual ranging is also possible. When an inappropriate range is selected, OF or UF is displayed on DISPLAY A or DISPLAY B.

3-32. CIRCUIT MODE

3-33. An impedance can be represented by a simple series or parallel equivalent circuit consisting of resistive and reactive elements. This is possible because both equivalent circuits have identical impedances at a given test frequency by properly establishing the values of the equivalent circuit elements. The equivalent circuit measurement mode is selected by setting the CIRCUIT MODE control. When the CIRCUIT MODE is set to AUTO, the 4276A will automatically select the circuit mode most appropriate for the range and function settings. Equivalent series circuit mode is automatically selected when the measurement range is inside the area enclosed in the dotted line in Figure 3-16. Equivalent parallel circuit mode is automatically selected when the measurement range is outside the area enclosed in the dotted line in Figure 3-16. By setting CIRCUIT MODE manually, either circuit mode can be selected, regardless all measurement ranges.

3-34. Capacitance and inductance measurements can be performed in either equivalent series circuit mode or equivalent parallel circuit mode. However, measured values obtained in each mode are different. The difference in measured values is related to the loss factor of the sample being measured. The impedance of a sample measured in both series and parallel circuit mode is the same at a particular frequency. Therefore, the following equations are satisfied:



$$G + jB = \frac{1}{R + jX}$$

$$= \frac{R}{R^2 + X^2} - j \frac{X}{R^2 + X^2}$$

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Expanding the above equation, we have

$$G + j\omega C_p = \frac{R}{R^2 + \frac{1}{\omega^2 C_s^2}} + j \frac{\frac{1}{\omega C_s}}{R^2 + \frac{1}{\omega^2 C_s^2}}$$

where, $C_s (= -\frac{1}{\omega X})$: equivalent series circuit capacitance

$C_p (= \frac{B}{\omega})$: equivalent parallel circuit capacitance

Obviously, if no series resistance (R) or parallel conductance (G) are present, the equivalent series circuit capacitance (Cs) and equivalent parallel circuit capacitance (Cp) are identical. Likewise, if R and G are not present, the equivalent series circuit inductance (Ls) and equivalent parallel circuit inductance (Lp) are identical.

However, a sample value measured in a parallel measurement circuit can be correlated with that of a series circuit by a simple conversion formula which covers the effect of dissipation factor. See Table 3-8. Figure 3-4 graphically shows the relationships of parallel and series parameters for various dissipation factor values. Applicable diagrams and equations are given in the chart. For example, a parallel capacitance

(Cp) of 1000pF with a dissipation factor of 0.5 is equivalent to a series capacitance (Cs) of 1250pF with an identical dissipation factor. As shown in Figure 3-4, inductance or capacitance values for parallel and series equivalents are nearly equal when the dissipation factor is less than 0.03. The dissipation factor of a component always has the same value at a given frequency for both parallel and series equivalents.

In ordinary LCR measuring instruments, the measurement circuit is set (automatically or manually) to a predetermined equivalent circuit with respect to either the selected range or to the dissipation factor value of the sample. The wider circuit mode selection capability of the 4276A, which is free from these restrictions, permits taking measurements in the desired circuit mode and of comparing such measured values directly with those obtained by another instrument. This obviates the inconvenience and necessity of employing instruments capable of taking measurements with the same equivalent circuit to assure measurement result correspondence.

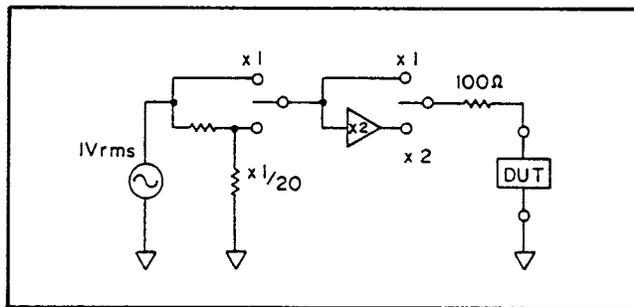


Figure 3-3. Equivalent Circuit of the Test Signal Source.

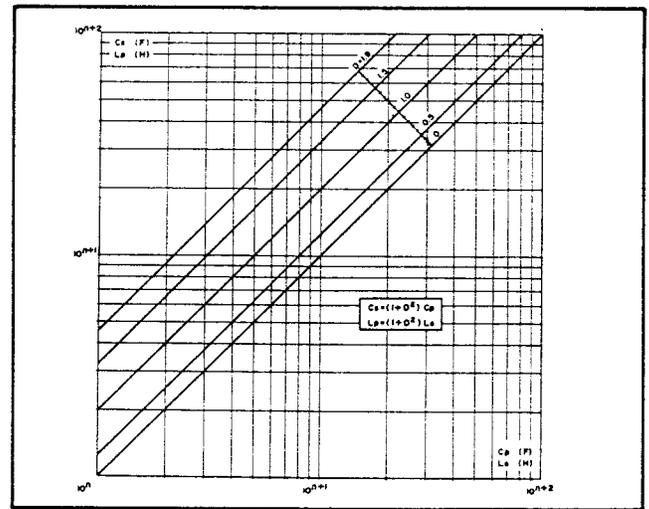


Figure 3-4. Parallel and Series Parameter Relationship.

Table 3-8. Dissipation Factor Equations and Equivalent Circuit Conversion Formulas

| Circuit Mode | Dissipation Factor | Conversion to Other Modes |
|--------------|---|--|
| C |  $D = \frac{G}{\omega C_p} = \frac{1}{Q}$ | $C_s = (1 + D^2) C_p, R = \frac{D^2}{1 + D^2} \cdot \frac{1}{G}$ |
| |  $D = \omega C_s R = \frac{1}{Q}$ | $C_p = \frac{1}{1 + D^2} C_s, G = \frac{D^2}{1 + D^2} \cdot \frac{1}{R}$ |
| L |  $D = \omega L_p G = \frac{1}{Q}$ | $L_s = \frac{1}{1 + D^2} L_p, R = \frac{D^2}{1 + D^2} \cdot \frac{1}{G}$ |
| |  $D = \frac{R}{\omega L_s} = \frac{1}{Q}$ | $L_p = (1 + D^2) L_s, G = \frac{D^2}{1 + D^2} \cdot \frac{1}{R}$ |

SECTION III

3-35. INITIAL DISPLAY AND INDICATIONS

3-36. Each time the instrument is turned on, the option codes for installed options and the HP-IB address are displayed on the front panel for approximately two seconds. The HP-IB address is displayed on DISPLAY A, as shown below. The factory set address is 17 (10001), but any address from 0 (00000) to 30 (11110) can be set. Refer to the HP-IB discussion starting in paragraph 3-72.

DISPLAY A



Note

If the instrument is set to TALK ONLY mode, the output data format number (see paragraph 3-95) will appear on DISPLAY A instead of the HP-IB address.

The following option code is displayed on DISPLAY B if the instrument is equipped with Option 002, Comparator/Handler Interface.

DISPLAY B



Note

The above option code will not be displayed if the 16064A Comparator/Handler Interface is not connected to the instrument.

The following option code is displayed on the FREQUENCY/DC BIAS display if the instrument is equipped with Option 001, Internal DC Bias.

FREQUENCY / DC BIAS



3-37. After the HP-IB address and option codes have been displayed, the continuous memory function automatically recalls the front panel control settings that existed when the instrument was turned off.

Note

Output from the internal dc bias source (option 001 instruments) is automatically set to 0V at instrument power on as a safety precaution.

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3-38. INITIAL CONTROL SETTINGS

3-39. The 4276A is automatically set to the control settings listed below when the continuous memory function (refer to paragraph 3-40) is reset as described in paragraph 3-42.

```

DISPLAY A Function..... C
DISPLAY B Function..... G
CIRCUIT MODE..... AUTO
LC|Z| RANGE..... AUTO
MEASUREMENT SPEED..... MED
TEST SIGNAL LEVEL..... HIGH
TRIGGER ..... INT
SELF TEST ..... OFF
Δ ..... OFF
FREQ/DC BIAS..... FREQ
SPOT/COARSE/FINE ..... SPOT
Frequency ..... 1.00kHz
OPEN ZERO DATA ..... 0Ω
SHORT ZERO DATA ..... OS

```

When the instrument is equipped Option 001:

```
DC BIAS ..... .00V
```

When the instrument is equipped Option 002, control settings of the 16064A Comparator are as follows:

```

ENABLE ..... OFF
LC|Z|//D/Q/ESR/G ..... L/C|Z|
LIMIT LOW/HIGH ..... LOW
BIN NUMBER ..... 1
RUN ..... OFF
BIN LIMITS ..... blank

```

3-40. CONTINUOUS MEMORY

3-41. The continuous memory function of the 4276A automatically memorizes all front panel control settings when the instrument is turned off or experiences a power failure. When the instrument is turned on, the memorized settings are automatically recalled. Continuous memory is powered by a rechargeable 2.4V nickel-cadmium battery that lasts for approximately 2 weeks when the instrument is turned off. The battery is recharged while the 4276A is turned on.

Note

It takes approximately 24 hours to recharge up the battery.

Note

When turned on, the 4276A automatically performs a Check Sum Test as part of its turn-on Self Test. The Check Sum Test checks the contents of memory. If incorrect, E68 will be displayed on DISPLAY A and memory will be cleared. The instrument will be set to the initial control settings (refer to paragraph 3-38).

OPEN and SHORT Zero Offset values (refer to paragraph 3-48) and reference values for deviation measurements (refer to paragraph 3-57) are also memorized by the continuous memory function. On instruments equipped with the Comparator/Handler Interface option (Option 002), all high and low limits and all 16064A control settings (except RUN) are memorized. DC bias voltage (Option 001) settings, however, are not memorized.

3-42. RESETTING CONTINUOUS MEMORY

3-43. To reset, or clear, continuous memory, proceed as follows:

- (1) Turn off the 4276A.
- (2) Press and hold both FREQ/DC BIAS Step Control Keys ( ).
- (3) Turn on the 4276A.

SECTION III

3-44. UNKNOWN TERMINALS

3-45. The UNKNOWN terminals of the 4276A are arranged in a five-terminal configuration. The five-terminal configuration provides accurate measurements over a broad impedance range. Low impedance errors caused by residual inductance and residual resistance, are lower than those of measurements made using the three-terminal configuration. Also, high impedance measurement errors caused by residual conductance and residual capacitance are lower than those of measurements made using the four-terminal configuration.

In the five-terminal configuration, the current through the DUT is fed back to the oscillator via the outer conductors of L_{CUR} and H_{CUR} terminals so as to reduce electromagnetic coupling between the current terminals (H_{CUR} and L_{CUR}) and the voltage terminals (H_{POT} and L_{POT}). This feature reduces the voltage detection error when a low-impedance DUT is measured at a high frequencies. Refer to Figure 3-5.

Note

It is recommended that four short BNC cables be used as test leads.

Note

Do not connect the outer conductors of the test leads to ground. If the outer conductors are grounded, displayed values will fluctuate when a low-impedance measurement is made at high frequencies.

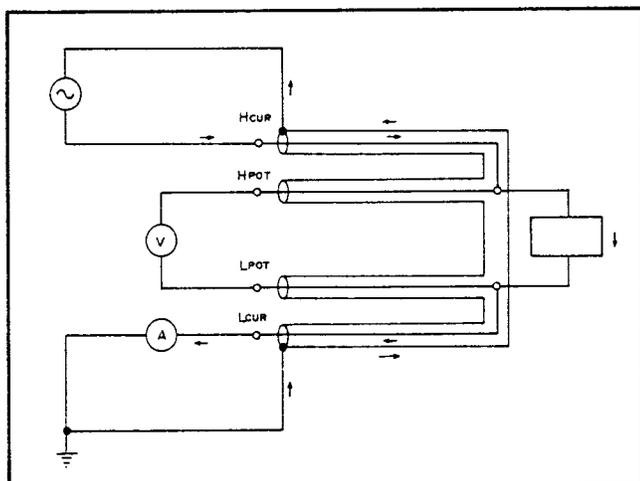


Figure 3-5. Five Terminal Configuration.

3-46. MEASUREMENT OF GROUNDED SAMPLES

3-47. Samples which have one terminal (except GROUND terminal) grounded to earth cannot normally be measured by the 4276A. Such measurement conditions are, for example, the distributed capacitance measurement of a coaxial cable with a grounded shield conductor or the input/output impedance measurement of a single ended amplifier. When a one-side-grounded sample is connected for measurement, the 4276A may display a measurement error message or incorrect measurement results. This is because the current through the DUT does not flow in the I-to-V Converter which converts the current to the voltage, with LOW measurement terminals grounded.

Note

If HIGH terminals are grounded, the test signal is not supplied to the DUT.

3-48. ZERO OFFSET ADJUSTMENT

3-49. The test fixtures and test leads used to connect samples to the instrument's UNKNOWN terminals have inherent residual impedance and stray admittance which, unless compensated for in some way, affect measurement accuracy. To minimize the effects of these residuals and strays, the 4276A is equipped with OPEN and SHORT Zero Offset Adjustment functions that can be executed from the front panel or via the HP-IB. Each Zero Offset Adjustment is performed at the following frequencies:

| | | | | |
|-------|-------|-------|-------|------|
| 20kHz | 16kHz | 10kHz | 5kHz | 2kHz |
| 1kHz | 500Hz | 200Hz | 100Hz | |

Zero Offset data for test frequencies other than those listed above are calculated from the Zero Offset data obtained at the above test frequencies by using second degree interpolation. Thus, Zero Offset is provided for measurements made at all test frequencies. Brief descriptions of the Zero Offset Adjustments (OPEN and SHORT) are given below.

ZERO OPEN:

The procedure for performing OPEN Zero Offset Adjustment is as follows:

- (1) Connect the test fixture or test leads to the instrument's UNKNOWN terminals.

Note

If test leads are used, you must convert the five-terminal configuration to a two-terminal configuration. Refer to paragraph 3-44 and Figure 3-5.

- (2) Connect nothing as the DUT.
- (3) Press the ZERO OPEN button.

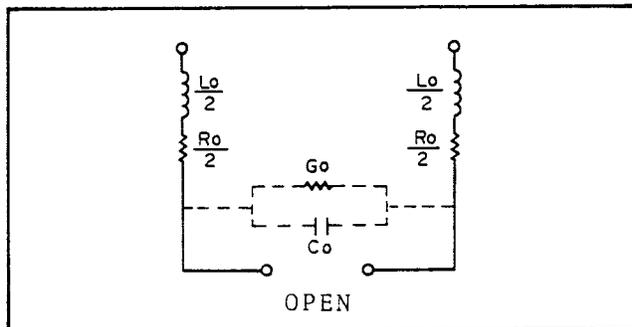


Figure 3-6. ZERO OPEN Circuit.

When the ZERO OPEN button is pressed, the instrument will be automatically set to C-G measurement mode. It will then measure the test fixture's stray admittance at each of the previously mentioned test frequencies. The measured values are stored in the instrument's internal memory. When offset adjustment is completed, DISPLAY A and DISPLAY B will be blank for 1 or 2 seconds, after which the front panel controls will be reset to the settings that existed when the ZERO OPEN button was pressed.

The purpose of OPEN Zero Offset Adjustment is to measure the test fixture's stray admittance, which, as shown in Figure 3-6, consists of G and C. (This stray admittance is equivalent to a high impedance, which will "swamp out" a high impedance DUT connected to the test fixture.) The residual impedance of the test fixture— R_0 and L_0 in Figure 3-6—is negligibly low and therefore does not affect the accuracy of OPEN Zero Offset Adjustments.

ZERO SHORT:

The procedure for performing SHORT Zero Offset Adjustment is as follows:

- (1) Connect the test fixture or test leads to the instrument's UNKNOWN terminals.

Note

If test leads are used, you must convert the five terminal configuration to a two-terminal configuration. Refer to paragraph 3-44 and Figure 3-5.

- (2) Connect a low impedance shorting-bar to the test fixture. If you're using test leads, simply connect the ends of the leads together.
- (3) Press the ZERO SHORT button.

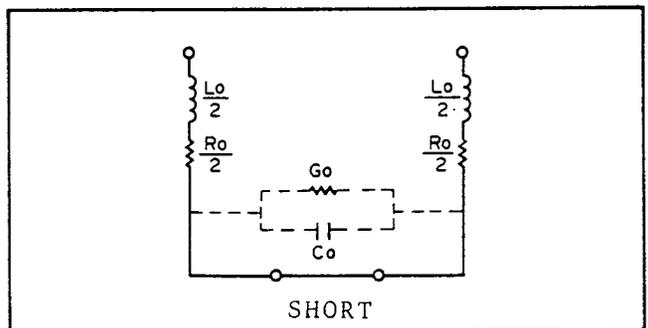


Figure 3-7. ZERO SHORT Circuit.

SECTION III

When the ZERO SHORT button is pressed, the instrument will be automatically set to $|Z|-\theta$ measurement mode. It will then measure the test fixture's residual impedance at each of the previously mentioned test frequencies. The measured values are stored in the instrument's internal memory. When offset adjustment is completed, DISPLAY A and DISPLAY B will be blank for 1 or 2 seconds, after which the front panel controls will be reset to the settings that existed when the ZERO SHORT button was pressed. The purpose of SHORT Zero Offset Adjustment is to measure the test fixture's (or test lead's) residual impedance, which, as shown in Figure 3-7, consists of R_0 and L_0 . This residual impedance, although small, degrades the accuracy of low impedance measurements. The stray admittance of the test fixture— G_0 and C_0 in Figure 3-7—is shunted by the low impedance shorting-bar and therefore is not measured.

Once OPEN and SHORT Zero Offset Adjustments have been made, the instrument automatically compensates all subsequent measurements for the residuals and strays of the test fixture or test leads. The values displayed on the front panel are the actual values of the DUT. Also, because the Zero Offset data is maintained by the instrument's continuous memory function, OPEN and SHORT Zero Offset Adjustments do not have to be repeated each time the instrument is turned on. You need to repeat Zero Offset Adjustments only when you change test fixtures (the residuals and strays of one test fixture are different from those of another). Maximum values that can be offset are listed below.

| | | |
|--------------|-----------------|-------|
| Capacitance: | Up to 20pF | OPEN |
| Conductance: | Up to $2\mu S$ | |
| Impedance: | Up to 2Ω | SHORT |

Note

During Zero Offset Adjustment, OF or CF may appear on DISPLAY A or DISPLAY B. Zero Offset Adjustment, however, is performed correctly unless error code "E10" is displayed.

Note

After Zero Offset Adjustments, CF and 0000 may be alternately displayed on DISPLAY A if the measurement mode is other than C-G and nothing is connected to the test fixture. This is normal; it is not a malfunction.

Note

OPEN and SHORT Zero Offset Adjustments cannot be performed without a test fixture.

3-50. ACTUAL MEASUREMENT EQUIVALENT CIRCUIT

3-51. The test fixture or test leads used to connect a sample to the instrument's UNKNOWN terminals becomes part of the sample which the instrument measures. The five terminal configuration employed in the 4276A minimizes residual impedance circuit. The residual impedance, inherent in the test fixture or test leads, can be eliminated by the 4276A's ZERO offset function (refer to paragraph 3-48).

However, the five terminal measurement system must be converted to a two terminal configuration at the sample because most components have only two terminals. Moreover, additional stray capacitance is introduced when the sample is connected to the test fixture. Figure 3-8 illustrates lead impedance and the stray capacitances between the component's leads.

3-52. Diverse parasitic elements present between the sample and the UNKNOWN terminals will affect measurement results. These parasitic elements are series resistive and reactive elements and parallel conductive and susceptive elements. Figure 3-9 shows the equivalent circuit of the sample's parasitic elements ($R + jX$ is the sample's impedance). In Figure 3-9, L_0 represents the residual inductance of the component's leads, and R_0 is lead resistance. G_0 is the conductance between the leads, and C_0 is the sum of all stray capacitances shown in Figure 3-8. Reactive factors in the residual impedance and susceptive factors in the stray admittance have a greater effect on measurements made at higher frequencies.

3-53. Figure 3-10 shows the effect of residual impedance on C-G measurement and the effect of stray admittance on L-R measurement. Generally, L_0 resonates with the capacitance of the sample (series resonance) and C_0 resonates with the inductance of the sample (parallel resonance), respectively, at a specific high frequency. Thus, the impedance of the test sample will have a minimum value corresponding to resonant peaks, as shown in Figure 3-11. The presence of L_0 and C_0 causes measurement errors, as the phase of the test signal current varies over a broad frequency region around the

Model 4276A

resonant frequencies. Additional errors, due to the resonance, increase in proportion to the square of the measurement frequency (below resonant frequency) and can be theoretically approximated as follows:

$$C_{\text{ERROR}} = \omega^2 L_0 C_X \cdot 100 (\%)$$

$$L_{\text{ERROR}} = \omega^2 C_0 L_X \cdot 100 (\%)$$

where,

- ω = $2\pi f$ (f : test frequency)
- C_X = Capacitance value of sample
- L_X = Inductance value of sample

At low frequencies, L_0 and C_0 affect measured inductance and capacitance values, respectively, as simple additive errors. These measurement errors cannot be fully eliminated by the ZERO offset adjustment (which compensates for residual factors inherent in the test fixture). This is because L_0 and C_0 are peculiar to the component being measured. Their values depend on component lead length and on the distance between the sample and test fixture. The measurement results, then, are substantially the sample values including the parasitic impedances present under the conditions necessary to connect and hold the sample.

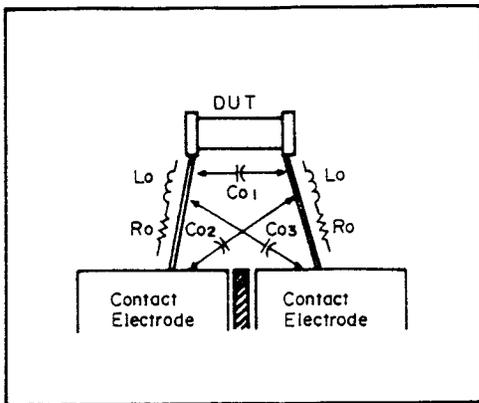


Figure 3-8. Parasitic Elements Incident to DUT Connections.

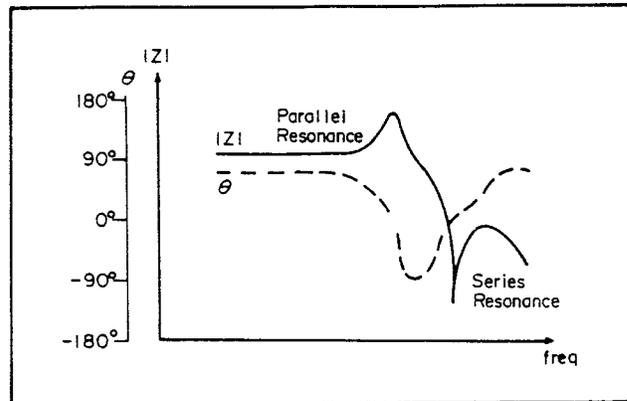


Figure 3-11. Effect of Resonance in Sample (Example).

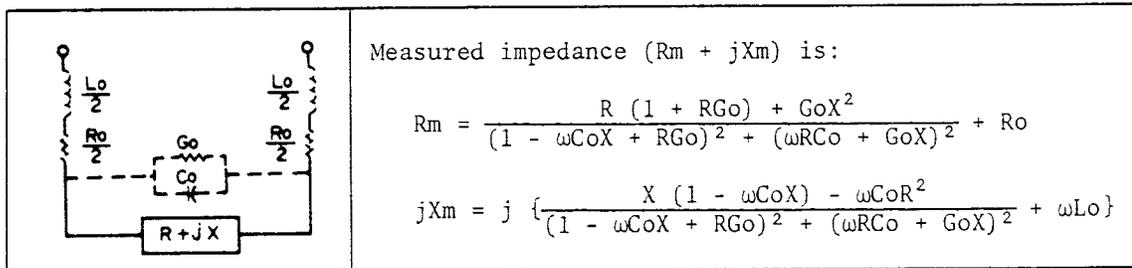


Figure 3-9. Equivalent Circuit Including Residual Impedance.

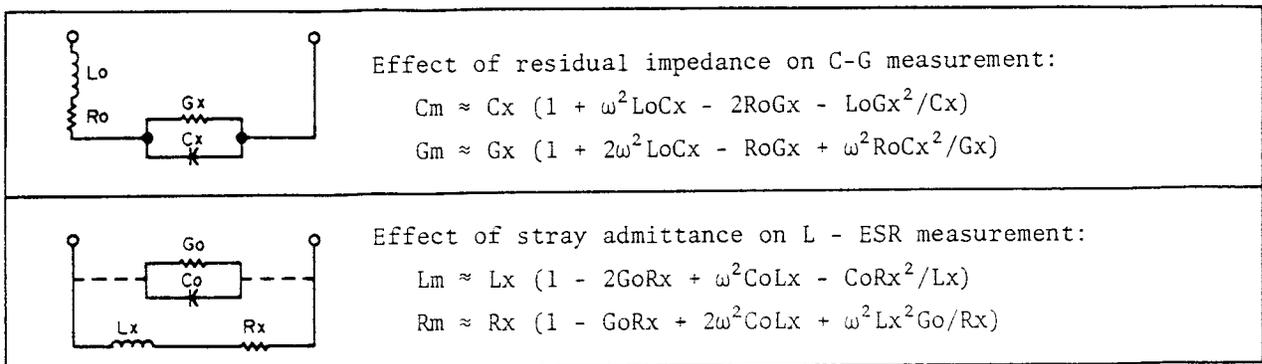


Figure 3-10. Effects of Residual Impedance.

3-54. MEASURED VALUES AND BEHAVIOR OF COMPONENTS

3-55. A component's measured value and its nominal value can, and often do, differ considerably because of various electromagnetic effects; for example, skin-effect of a conductor, the ferromagnetic properties of inductors, and the effects of dielectric materials in capacitors. Here, will discuss only the effects which result from the interaction of the reactive elements (L, C, etc.) of a component.

3-56. The impedance of a component can be graphically represented in vector form as shown in Figure 3-12. In such representation, the effective resistance and effective reactance correspond to the projections of the impedance vector $|Z| \angle \theta$; that is, the real (R) axis and the imaginary (jX) axis, respectively, as shown below:

$$\begin{aligned} Re &= |Z| \cos \theta \\ Xe &= |Z| \sin \theta \\ D &= \frac{\cos \theta}{\sin \theta} = \frac{1}{\tan \theta} \end{aligned}$$

- where, Re: Effective resistance
- Xe: Effective reactance
- Z: Impedance of the sample (Re + jXe).
- D: Dissipation factor

When the phase angle, θ , changes, both Re and Xe change in accordance with the definitions above. As component measurement parameters L, C, R, D, etc., are also representations of components related to the impedance vector, the phase angle dominates their values. Consider, for example, the inductance and the loss of an inductive component at frequencies around its self-resonant frequency. Figure 3-13 shows the equivalent circuit of the inductor. The inductance, L_x , resonates with the distributed capacitance C_0 at frequency f_0 . The phase angle (θ) of the impedance vector approaches 0 degrees (the vector approaches the R axis) when the frequency is close to the resonant frequency. Thus, the inductance of this component decreases while the resistive factor (loss) increases. At the resonant frequency, f_0 , this component is purely resistive. The effective resistance increases at resonance even if the inductor has no resistance (ideal inductor) at dc. Consequently, the loss factor varies sharply at frequencies around the resonant point.

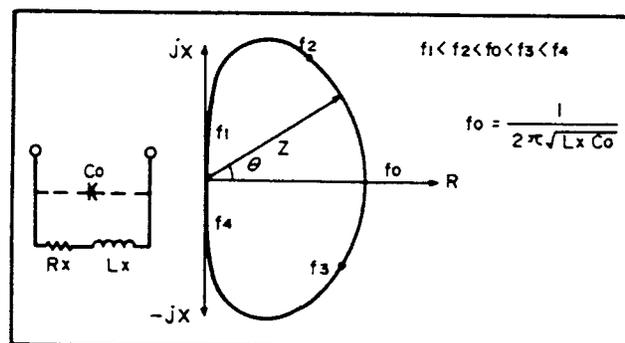
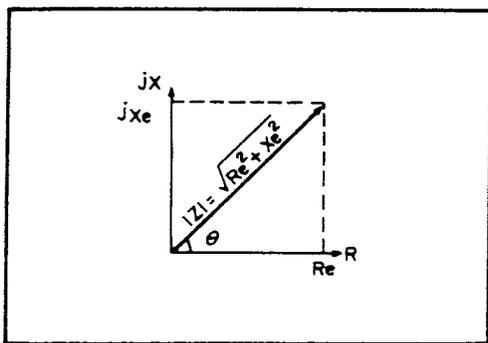


Figure 3-12. Impedance Vector Representation.

Figure 3-13. Typical Impedance Locus of an Inductor.

Model 4276A

3-57. DEVIATION MEASUREMENT FUNCTION

3-58. When many components of similar value are to be tested, it may be more practical to measure the difference between the value of the component and a predetermined, or ideal, reference value than measuring the DUT value itself. When the purpose of the measurement is to observe the change of a component's value versus changes in temperature, frequency, bias, etc., a direct measurement of this change (deviation) makes examination more meaningful and easier.

When the key is pressed, the values (measurement results) displayed on DISPLAY A and DISPLAY B are stored in the instrument's memory and are then used as the reference values for all subsequent measurements. The value displayed on each display is not the sample's measured value, it is the difference between the stored reference value and the measured value. Stored reference values are maintained by the 4276A's continuous memory function when the instrument is turned off. The deviation measurement function is automatically turned off when the DISPLAY A function, DISPLAY B function, LC|Z|RANGE, or CKT MODE is changed. It may be turned off also if the test frequency is changed when the DISPLAY B function is ESR/G, because the measurement range for ESR and G is frequency dependent.

3-59. CHARACTERISTICS OF TEST FIXTURES

3-60. Characteristics and applicable measurement ranges of the HP test fixtures and test leads for the 4276A are summarized in Table 3-9. To facilitate measurement and to minimize measurement errors, a test fixture appropriate for the measurement should be chosen from among HP's standard accessories. Select the test fixture or leads that have the desired performance characteristics.

Table 3-9 . Typical Characteristics of Test Fixtures and Leads

| Model | Applicable Measurement Ranges | |
|------------------|--------------------------------------|-----------------------|
| | Parameter Value | Measurement Frequency |
| 16047A | Full range | Full range |
| 16047C | Full range | Full range |
| 16048A 16048B | Full range | Full range |
| 16048C | C>1000pF L>100μH | Below 100kHz |
| 16048D | Full range | Full range |
| 16034B | Ranges satisfied $ Z > 50\Omega$ | Full range |
| 16065A | Full range | 50Hz to 2MHz |

3-61. RANGE RESISTOR

3-62. The relation between the range resistor value and the measurement range is listed in Figure 3-16.

SECTION III

3-63. MEASUREMENT ACCURACY

3-64. The measurement reference plane for the accuracies specified in Section I is the UNKNOWN terminals. The measurement accuracy of the 4276A is guaranteed at the UNKNOWN terminals. The conditions under which accuracy is specified are described in Table 1-1. An example of the how to calculate measurement accuracy is shown in Figure 3-15.

3-65. MEASUREMENT EXAMPLE

3-66. The procedures for measuring general components—inductors, capacitors, resistors—are given in Figure 3-17. Almost any discrete component, except for those having special shapes or dimensions, can be measured with this setup. Special components may be measured by using test leads 16048A, 16048D, 16034B, etc., or by using specially designed user-built fixtures instead of the 16047A Test Fixture.

3-67. As an example of a typical semiconductor measurement, the procedures for measuring the base-collector junction capacitance (C_{ob}) of an NPN transistor are given in Figure 3-18.

3-68. EXTERNAL DC BIAS

3-69. The special biasing circuits and procedures for using external voltage or current bias (required for certain capacitance or inductance measurements) are given in Figures 3-19, 3-20, and 3-21. The figures show sample circuits appropriate for 4276A applications. When applying a dc voltage to capacitors, be sure the applied voltage does not exceed the maximum specified voltage of the capacitor and that the capacitor is connected with correct polarity. Note that the externally applied bias voltage is present at the H_{CUR} and H_{POT} terminals.

3-70. EXTERNAL TRIGGERING

3-71. The 4276A can be externally triggered by connecting an external triggering device to the EXT TRIGGER connector on the rear panel and setting the TRIGGER control on the front panel to MAN/EXT on front panel. The instrument is triggered (measurement is made) each time a positive-going TTL level pulse is applied to this connector (refer to Figure 3-14). External triggering can be also done by alternately shorting and opening the center conductor of the EXT TRIGGER connector to ground (chassis).

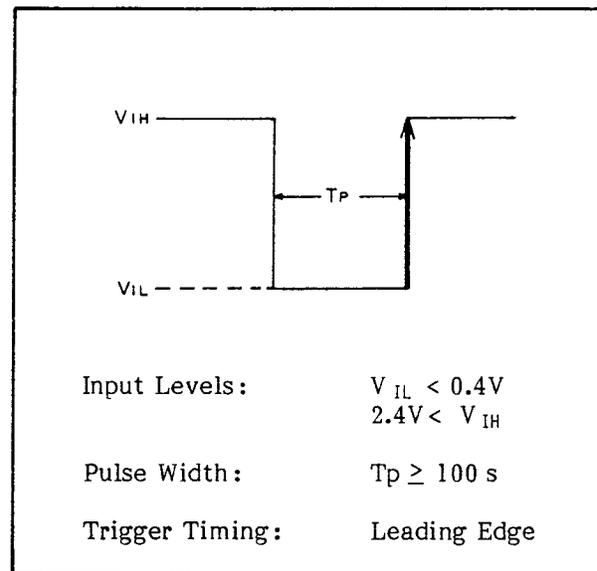


Figure 3-14. External Trigger Pulse.

[Examples of Calculating C, D, and Q Measurement Accuracies]

Front Panel Settings:

Test Frequency: 1kHz
 LC|Z| RANGE: 1nF
 TEST SIG LEVEL: HIGH
 MEAS SPEED: MED

Measured Values:

C: 1.9945nF
 D: .0008
 Q: OF (Assume a value of Q_m)

Accuracies (Refer to Table 1-1):

C: $\pm 0.1\%$ of reading + 5 counts
 $1.9945\text{nF} \times (.1/100) + .0005\text{nF}$
 $= (\pm) 2.49\text{pF}$
 D: $\pm 0.1\%$ of reading + .0006A + 5 counts
 $.0008 \times (.1/100) + .0006 \times 1.248 + .0005$
 $= (\pm) .00125$
 Q: $Q_m \times (.00125/.0008) + .1$
 $= \pm (Q_m \times 1.5625 + .1)$

Note

In this case, Q accuracy (1.5625 times Q_m) has no meaning, because Q_m is overflow (OF).

[Examples of Calculating C and ESR/G Measurement Accuracies]

Front Panel Settings:

Test Frequency: 10kHz
 LC|Z| RANGE: 1 μ F
 TEST SIG LEVEL: HIGH
 MEAS SPEED: MED

Measured Values:

C: .852 μ F
 ESR: .42 Ω
 G: 1.2mS

Accuracies:

C: $.9\%$ of reading + 2 counts
 $.852\mu\text{F} \times (.9/100) + .002\mu\text{F}$
 $= (\pm) 9.67\text{nF}$
 ESR: $.6\%$ of reading + .6/ $\alpha\Omega$ + 5 counts
 $.42\Omega \times (.6/100) + .6/.852 + .05\Omega$
 $= (\pm) .757\Omega$
 G: $1.2\text{mS} \times (.757/.42) + .1\text{mS}$
 $= (\pm) 2.16\text{mS}$

Figure 3-15. How to Calculate Measurement Accuracies.

SECTION III

C-D Measurement

| C Range | Test Frequency (Hz) | | |
|-------------|---------------------|----------------|------------|
| | 100 ~ 199 | 200~1.99k | 2 k ~ 20 k |
| 10 mF | | | |
| 1 mF | | | |
| 100 μ F | | 100 Ω | |
| 10 μ F | | | |
| 1 μ F | | | |
| 100 nF | | 1 k Ω | |
| 10 nF | | 10 k Ω | |
| 1 nF | | 100 k Ω | |
| 100 pF | | | |
| 10 pF | | | |

L-D Measurement

| L Range | Test Frequency (Hz) | | |
|-------------|---------------------|----------------|-------------|
| | 100 ~ 995 | 1 k ~ 9.95 | 10 k ~ 20 k |
| 1 kH | | | |
| 100 H | | 100 k Ω | |
| 10 H | | 1 k Ω | |
| 1 H | | 1 k Ω | |
| 100mH | | | |
| 10mH | | 100 Ω | |
| 1mH | | | |
| 100 μ H | | | |

C-ESR/G Measurement

| ESR/G Range | Test Frequency (Hz) | | |
|------------------------------|---------------------|----------------|------------|
| | 100 ~ 498 | 500~4.98 k | 5 k ~ 20 k |
| 10 M Ω / 1 μ S | | | |
| 1 M Ω / 10 μ S | | 100 k Ω | |
| 100 k Ω / 100 μ S | | 10 k Ω | |
| 10 k Ω / 1mS | | 1 k Ω | |
| 1 k Ω / 10mS | | | |
| 100 Ω / 100mS | | 100 Ω | |
| 10 Ω / 1S | | | |
| 1 Ω / 10S | | | |

L-ESR/G Measurement

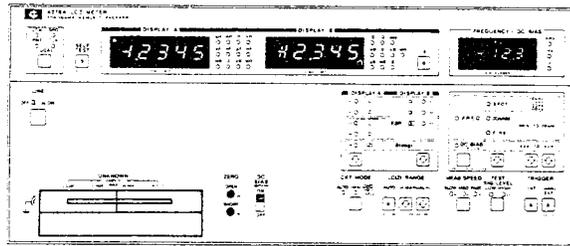
| ESR/G Range | Test Frequency (Hz) |
|------------------------------|---------------------|
| | 100 ~ 20 k |
| 1 M Ω / 10 μ S | 100 k Ω |
| 100 k Ω / 100 μ S | 10 k Ω |
| 10 k Ω / 1mS | 1 k Ω |
| 1 k Ω / 10mS | |
| 100 Ω / 100mS | 100 Ω |
| 10 Ω / 1S | |

|Z| - θ Measurement

| Z Range | Test Frequency (Hz) |
|----------------|---------------------|
| | 100 ~ 20 k |
| 10 M Ω | |
| 1 M Ω | 100 k Ω |
| 100 k Ω | 10 k Ω |
| 10 k Ω | 1 k Ω |
| 1 k Ω | |
| 100 Ω | |
| 10 Ω | 100 Ω |
| 1 Ω | |

Figure 3-16. Range Resistor.

GENERAL MEASUREMENT



1. Connect the 16047A Test Fixture to the UNKNOWN terminals.
2. Turn on the 4276A.
3. Verify that the HP-IB address and option codes (16064 and 001) are displayed on DISPLAY A, DISPLAY B, and the FREQUENCY/DC BIAS display, respectively.
4. Press the SELF TEST key to verify that the instrument is functioning properly. Refer to paragraph 3-5, SELF TEST. If no error-codes are displayed, press the SELF TEST key again to turn off the SELF TEST function.
5. Select the measurement functions for DISPLAY A and DISPLAY B.
6. Set the test frequency, test signal level, and measurement speed.

Note

SLOW measurement speed minimizes display fluctuation.

Note

Best measurement accuracy is obtained when test signal level is set to HIGH and measurement speed is set to MED.

7. Perform OPEN and SHORT Zero Offset adjustments as described in paragraph 3-48.
8. Connect the device to be measured to the test fixture.
9. Read the measured values from DISPLAY A and DISPLAY B.

Note

Refer to paragraph 3-20 for the meaning of any error-codes that may appear on DISPLAY A.

Note

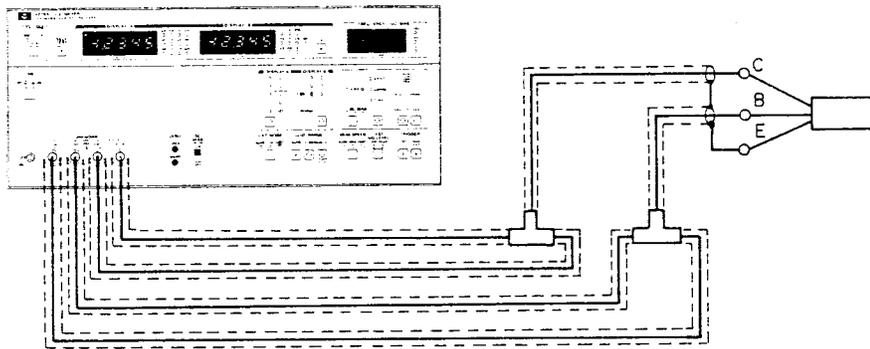
When the instrument is set to C-D or C-Q measurement mode and nothing is connected to the measurement terminals, CF and .0000 may be alternately displayed on DISPLAY A. This is not a malfunction, however.

Note

For C or L measurement, if the dissipation factor of the DUT is higher than 0.1, C, L, and D measurement accuracy tolerances increase by a factor of $1 + D^2$. If D is higher than 1, AUTO ranging cannot be performed correctly. |Z| measurement mode should be selected.

Figure 3-17. General Measurement.

SEMICONDUCTOR DEVICE MEASUREMENT



Parameters of semiconductor devices have a strong dependency on the applied voltage and device temperature. Because of the non-linear impedance characteristics of semiconductor devices, a semiconductor measurement is subject to exact establishment of the test conditions to make measured values meaningful. For a detailed analysis of the device under its operating test conditions, a low level test signal is employed in order to obtain measured values with respect to a local region around the operating test point selected for plotting characteristic parameter curves of the sample. A typical procedure for measuring semiconductor junction capacitance in P-N and MOS junction devices is outlined below.

Measurement Setup:

The figure above shows a typical test setup for measuring the base-collector junction capacitance (C_{ob}) of an NPN transistor. For this measurement, the test fixture may be user designed. A 4276A equipped with option 001 is ideal for controlling the dc bias required for the measurement. If dc bias is not necessary, setup and procedures associated with this measurement may be deleted.

PROCEDURE:

1. Connect the test fixture or test cables to the UNKNOWN terminals of the 4276A.
2. Turn on the 4276A.
3. Set the 4276A's front panel controls as follows:

```
DISPLAY A: C
DISPLAY B: G
Test Freq.: 1kHz
TEST SIG LEVEL: LOW
```

4. Perform OPEN and SHORT Zero Offset adjustments as described in paragraph 3-48.
5. Set the DC BIAS SELECT switch on the rear panel to INT.

Note

If an external voltage source is used for dc biasing, set the DC BIAS SELECT switch to EXT, and connect the voltage source output to the EXT INPUT/INT MONITOR connector on the rear panel.

Note

DC bias voltage, whether supplied from the internal bias source or from an external bias source, should be set to 0V at this time.

Note

Use the HP Model 16065A EXTERNAL VOLTAGE BIAS FIXTURE for high voltage bias applications up to $\pm 200V$.

6. Connect the transistor to the measurement terminals.
7. Monitor the bias voltage actually applied to the transistor.

Note

If the 16065A is used, close the lid after you connect the transistor to the measurement terminals. Measurement cannot be made while the lid is open.

8. Set the DC BIAS switch on the front panel to ON, and set the desired bias voltage.

Figure 3-18. Semiconductor Device Measurement (Sheet 1 of 2).

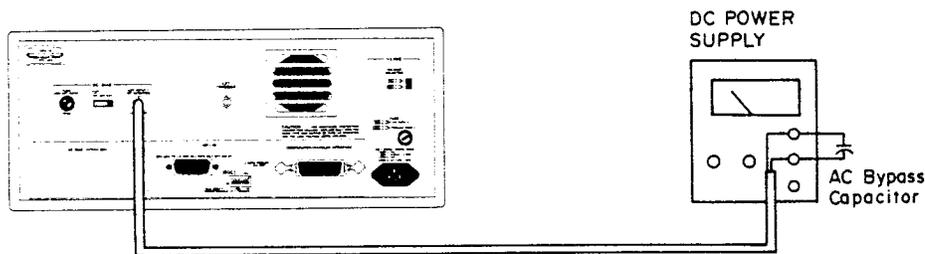
Note

If the P-N junction becomes forward biased at either peak of the test signal, correct measurement cannot be made.

9. Read the capacitance value from DISPLAY A.

Figure 3-18. Semiconductor Device Measurement (Sheet 2 of 2).

SECTION III

EXTERNAL DC BIAS OPERATION ($\leq \pm 40V$)

To make capacitance measurements using externally supplied dc bias voltages up to $\pm 40V$, connect a dc voltage source to EXT INPUT/INT MONITOR connector on the rear panel as shown in the diagram.

CAUTION

DO NOT APPLY GREATER THAN $\pm 40V$ TO THE 4276A'S EXT INPUT/INT MONITOR CONNECTOR. IF THE APPLIED VOLTAGE EXCEEDS $\pm 40V$, THE 4276A MAY BE DAMAGED.

CAUTION

BE SURE THE CORRECT FUSE (HP P/N 2110-0011) IS INSTALLED IN THE DC BIAS FUSE HOLDER ON THE REAR PANEL.

PROCEDURE:

1. Set DC BIAS select switch on rear panel to EXT.
2. Connect the test fixture or test leads to the UNKNOWN terminals of the 4276A.
3. Turn on the instruments.
4. Set the 4276A's controls as described in steps 3 through 6 of Figure 3-17. Set the DISPLAY A function to "C" measurement mode.
5. Perform OPEN and SHORT ZERO offset adjustments as described in paragraph 3-48.
6. Connect a sample to the test fixture or test leads.

CAUTION

DO NOT SHORT THE HIGH AND LOW TERMINALS.

CAUTION

WHEN A POSITIVE BIAS VOLTAGE IS USED, THE POSITIVE TERMINAL OF ELECTROLYTIC CAPACITORS MUST BE CONNECTED TO THE INSTRUMENT'S HIGH TERMINAL. WHEN USING A NEGATIVE BIAS VOLTAGE, CONNECT THE CAPACITOR'S NEGATIVE TERMINAL TO THE INSTRUMENT'S HIGH TERMINAL.

7. Set the external dc voltage source to the desired output voltage.
8. Read the measured values. Wait until the applied dc bias across the sample becomes stable.
9. Reset the external voltage source to 0V.
10. Remove the sample from test fixture or test leads.

Note

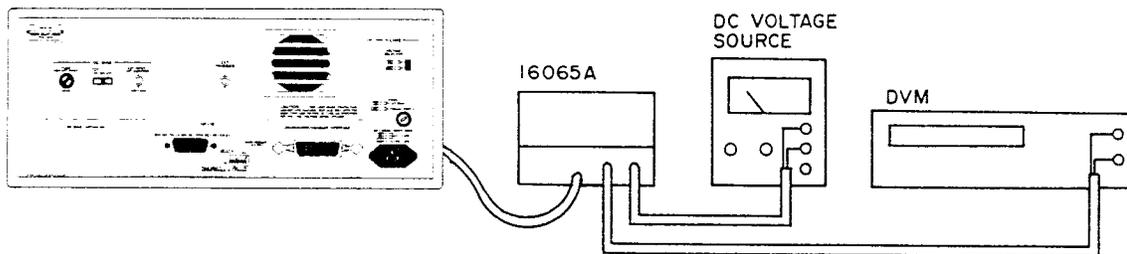
Use a stable dc voltage source.

Note

To make stable measurements, connect an ac bypass capacitor (approximately $1\mu F$) between positive terminal and negative terminal of the external dc voltage source.

Figure 3-19. External DC Bias Operation ($\leq \pm 40V$).

EXTERNAL DC BIAS OPERATION ($\leq \pm 200V$)



To make capacitance measurements using externally supplied dc bias voltages up to $\pm 200V$, use the HP 16065A Test Fixture. Connect a dc voltage source to the 16065A as shown in the diagram.

CAUTION

DO NOT APPLY GREATER THAN $\pm 40V$ TO THE 4276A'S EXT INPUT/INT MONITOR CONNECTOR. IF THE APPLIED VOLTAGE EXCEEDS $\pm 40V$, THE 4276A MAY BE DAMAGED.

PROCEDURE:

1. Set DC BIAS select switch on rear panel to OFF.
2. Connect the 16065A to the UNKNOWN terminals of the 4276A.
3. Connect the dc voltage source to DC BIAS INPUT connector of the 16065A.
4. Connect a DVM or an oscilloscope to the DC BIAS MONITOR connector of the 16065A.
5. Turn on the instruments.
6. Set the 4276A's controls as described in steps 3 through 6 (Figure 3-17). Set the DISPLAY A function to "C" measurement mode.
7. Perform OPEN and SHORT ZERO offset adjustments.
8. Connect a sample to the 16065A test fixture.

CAUTION

DO NOT SHORT THE HIGH AND LOW TERMINALS.

CAUTION

WHEN A POSITIVE BIAS VOLTAGE IS USED, THE POSITIVE TERMINAL OF ELECTROLYTIC CAPACITORS MUST BE CONNECTED TO THE INSTRUMENT'S HIGH TERMINAL. WHEN USING A NEGATIVE BIAS VOLTAGE, CONNECT THE CAPACITOR'S NEGATIVE TERMINAL TO THE INSTRUMENT'S HIGH TERMINAL.

9. Set the external dc voltage source to the desired output voltage and close the cover of the 16065A.
10. Read the measured values. Wait until the monitored voltage becomes stable.
11. Open the cover of the 16065A.

Note

When the cover of the 16065A is opened, the charge on the sample is discharged through two paralleled 20Ω resistors.

12. Remove the sample from the 16065A.

Note

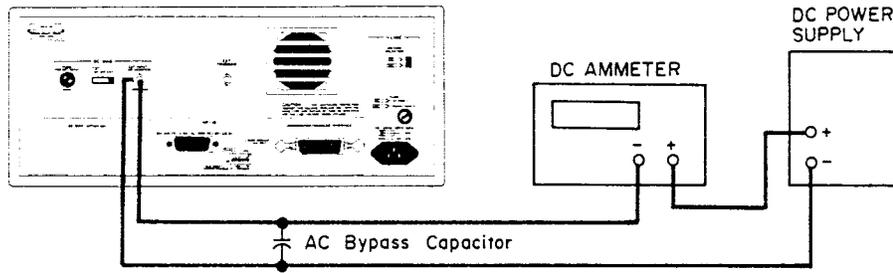
Use a stable dc voltage source.

Note

The test signal will appear at the DC BIAS MONITOR connector. This does not affect measurement results, however.

Figure 3-20. External DC Bias Operation ($\leq \pm 200V$).

EXTERNAL DC CURRENT BIAS OPERATION ($\leq 1\text{mA}$)



Note

DC bias current flowing through sample can be calculated by the following equation:

$$I_{DC} = \frac{E_{bias}}{R_x + 1} \text{ (mA)}$$

where E_{bias} is the bias voltage (V) applied to EXT INPUT/INT MONITOR connector and R_x is the dc resistance ($k\Omega$) of the sample.

PROCEDURE:

1. Set the DC BIAS select switch on the rear panel to EXT.
2. Connect an external dc voltage source and dc ammeter (for current monitoring) to the EXT INPUT/INT MONITOR connector on the rear panel, as shown in the diagram.
3. Connect a test fixture or test leads to the UNKNOWN terminals of the 4276A.
4. Turn on the instruments.
5. Set the 4276A's controls as described in steps 3 through 6 of Figure 3-17. Set the DISPLAY A function to "L" measurement mode.
6. Perform OPEN and SHORT ZERO offset adjustments.
7. Connect the sample to the test fixture or test leads.
8. Gradually increase the dc voltage source output voltage until the desired bias current, as indicated on the dc ammeter, is obtained.

9. Read the measured values.

10. Gradually decrease the dc voltage source output voltage until the dc bias current is 0mA, then remove the sample from the test fixture or test leads.

Note

To make stable measurements, connect an ac bypass capacitor (near $1\mu\text{F}$) between the positive terminal and the negative terminal of the dc voltage source.

Note

Maximum allowable current depends on the range resistor, as listed in the table below.

| Range Resistor Value | Maximum Current |
|----------------------|-----------------|
| 100Ω | 1mA |
| $1k\Omega$ | 0.5mA |
| $10k\Omega$ | $50\mu\text{A}$ |
| $100k\Omega$ | $5\mu\text{A}$ |

CAUTION

DO NOT ALLOW THE BIAS CURRENT TO EXCEED 35mA AND DO NOT ALLOW THE OUTPUT VOLTAGE FROM THE EXTERNAL DC VOLTAGE TO EXCEED SOURCE $\pm 40\text{V}$. IF CURRENT EXCEEDS 35mA OR IF VOLTAGE EXCEEDS $\pm 40\text{V}$, THE INSTRUMENT MAY BE DAMAGED.

Refer to Figure 3-16 for details on the relation between range resistor and measurement range. Note that measurement accuracies, as specified in Section I, are not guaranteed if bias current is allowed to exceed the limits given in the above table.

Figure 3-21. External DC Current Bias Operation ($\leq \pm 1\text{mA}$).

3-72. HP-IB INTERFACE

3-73. The 4276A can be remotely controlled via the HP-IB, a carefully defined instrument interface which simplifies integration of programmable instruments and a calculator or computer into a system.

Note

HP-IB is Hewlett-Packard's implementation of IEEE Std. 488, "Standard Digital Interface for Programmable Instrumentation."

3-74. HP-IB INTERFACE CAPABILITIES

3-75. The 4276A has eight HP-IB interface functions, as listed in Table 3-11.

Table 3-10. HP-IB Interface Capabilities

| Code | Interface Function * (HP-IB Capabilities) |
|--------|--|
| SH1 ** | Source Handshake |
| AH1 | Acceptor Handshake |
| T5 | Talker (basic talker, serial poll, talk only mode, unaddress to talk if addressed to listen) |
| L4 | Listener (basic listener, unaddress to listen if addressed to talk) |
| SR1 | Service Request |
| RL1 | Remote/local (with local lockout) |
| DC1 | Device Clear |
| DT1 | Device Trigger |

* Interface functions provide the means for a device to receive, process, and transmit messages over the bus.

** The numeric suffix of the interface code indicates the limitation of the function, as defined in Appendix C of IEEE Std. 488. 1978.

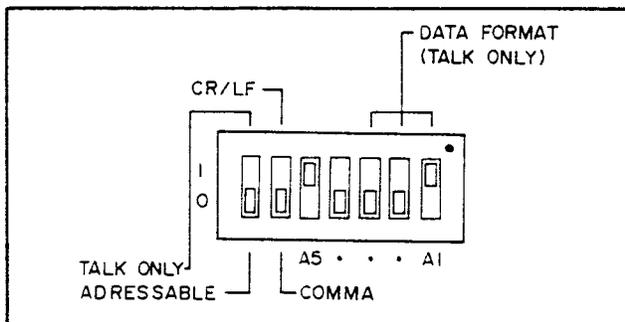


Figure 3-22. HP-IB Control Switch.

3-76. CONNECTION TO HP-IB

3-77. The 4276A can be connected into an HP-IB bus configuration with or without a controller (i.e., with or without an HP calculator). In an HP-IB system without a controller, the instrument functions as a "talk only" device (refer to paragraph 3-84).

3-78. HP-IB STATUS INDICATORS

3-79. The HP-IB Status Indicators are four LED lamps located on the front panel. When lit, these lamps show the existing status of the 4276A in the HP-IB system as follows:

SRQ: SRQ signal from the 4276A to the controller is on the HP-IB line. Refer to paragraph 3-101.

LISTEN: The 4276A is set to listener.

TALK: The 4276A is set to talker.

REMOTE: The 4276A is under remote control.

3-80. LOCAL KEY

3-81. The LOCAL key releases the 4276A from HP-IB remote control and allows measurement conditions to be set from the front-panel. The REMOTE lamp will go off when this key is pressed. LOCAL control is not available when the 4276A is set to "local lockout" status by the controller.

3-82. HP-IB CONTROL SWITCH

3-83. The HP-IB Control Switch, located on the rear panel, has seven bit switches. See Figure 3-22. Each bit switch has two settings: logical 0 (down position) and logical 1 (up position). The left-most bit switch, bit 7, determines whether the instrument will be addressed by the controller in a multidevice system, or will function as a "talk only" device to output measurement data and/or instructions to an external "listener," e.g., printer. The switch settings, when the instrument is shipped from the factory, are shown in Figure 3-22.

When bit switch 7 is set to 0, the instrument is in ADDRESSABLE mode and bit switches 1 through 5 determine the instrument address. When this bit switch is set to 1, however, the instrument is in TALK ONLY mode.

Bit switch 6 determines the output data delimiter. When this bit switch is set to 0, the delimiter is a comma (,); when set to 1, the delimiter is a carriage return and line feed (CR/LF).

SECTION III

Note

The HP-IB Control Switch setting is memorized only at instrument turn on. Thus, even if the HP-IB Control Switch setting is changed while the instrument is turned on, the memorized setting is not changed until the instrument is turned off and on.

3-84. TALK ONLY MODE

3-85. When bit switch 7 of the HP-IB Control Switch is set to TALK ONLY (i.e., set to 1), the instrument functions as a "talker," outputting data to a "listener" (e.g., printer). In TALK ONLY mode, bit switches 1, 2, and 3 determine the format in which data is output. There are six formats, F1 through F6, and the bit switch setting for each format is shown in Table 3-11. Refer to paragraph 3-95 for details on the output data formats.

Note

If the instrument is set to TALK ONLY mode, the Output Data Format number will be briefly displayed on DISPLAY A (instead of the HP-IB address) when the instrument is turned on. The displayed number, however, will be the format number plus 50. For example, if the Output Data Format is F2, the number displayed on DISPLAY A at turn on will be 52.



Note

When the instrument is used in TALK ONLY mode, devices connected to the instrument must be set to LISTEN ONLY mode.

3-86. In TALK ONLY mode, both bit switches 4 and 5 have no function.

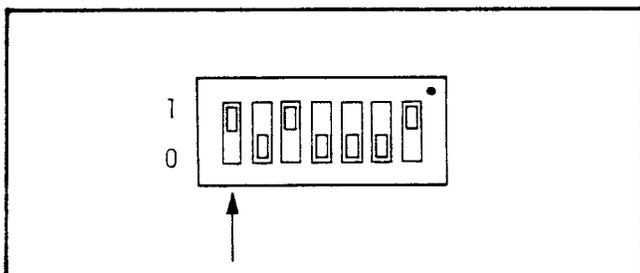


Figure 3-23. TALK ONLY Mode.

Table 3-11. Data Output Format Selection

| Bit Switch Settings | | | Output Data Format |
|---------------------|-------|-------|--------------------|
| Bit 3 | Bit 2 | Bit 1 | |
| 0 | 0 | 0 | F1 |
| 0 | 0 | 1 | F2 |
| 0 | 1 | 0 | F3 |
| 0 | 1 | 1 | F4 |
| 1 | 0 | 0 | F5 |
| 1 | 0 | 1 | F6 |
| 1 | 1 | 0 | F1 |
| 1 | 1 | 1 | F2 |

Note: Refer to paragraph 3-95 for details.

3-87. ADDRESSABLE MODE

3-88. When bit switch 7 of the HP-IB Control Switch is set to ADDRESSABLE (i.e., set to 0), bit switches 1 through 5 represent the HP-IB address of the instrument, in binary. These switches are set to 10001 (decimal 17) when the instrument leaves the factory but can be set to any desired address between 0 and 30.

Note

When the instrument is turned on, the HP-IB address is displayed, in decimal, on DISPLAY A. For example, the factory-set address (10001) is displayed as "17."



Note

HP-IB address 11111 (decimal 31) cannot be used. If this address is set, E19 will be displayed on DISPLAY A (after 31 has been displayed) when the instrument is turned on.

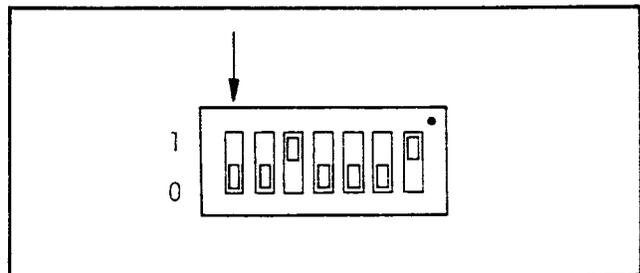


Figure 3-24. ADDRESSABLE Mode.

Model 4276A

3-89. REMOTE PROGRAM CODES

3-90. Remote program codes for the 4276A are listed in Table 3-12.

3-91. PARAMETER SETTING

3-92. Test frequency, DC bias (option 001), and bin limits (option 002) can be set via remote programming.

[1] Test Frequency Setting

FR $\frac{XXX.X}{(1)}$ EN

(1) Setting value, in kHz.

Note

When an illegal frequency that is within the instrument's frequency range is set, the frequency below the illegal setting is automatically selected. For example:

"FR7.59EN" 7.55kHz displayed on
FREQUENCY/DC BIAS
DISPLAY

[2] DC Bias setting

BI $\frac{\pm XX.X}{(1)}$ EN

(1) Setting value, in volts.

Note

If not set, polarity sign is automatically set to positive (+).

[3] Comparator Limit Setting (Option 002 only)

(Low Limit) LL $\frac{XX.XXX}{(1)}$ EN

(High Limit) LH $\frac{XX.XXX}{(1)}$ EN

(1) Setting value. The position of the decimal point must agree with the measurement range. Unit is in accordance with the unit indicators of DISPLAY A or DISPLAY B.

3-93. DATA OUTPUT

3-94. Measurement and status data are output to external devices in bit parallel, byte serial format via the eight DIO signal lines of the HP-IB. Data can be output in ASCII mode or

PACKED BINARY mode. Each mode is described below.

[1] ASCII mode

Output data in this mode includes status data, key status (function) data, and measurement data (including range) for DISPLAY A and DISPLAY B. If the instrument is equipped with Option 002, comparison data (LOW, IN, HIGH) for L/C/|Z| and D/Q/ESR/G, and BIN number data can be output, too. The output format is shown in Figure 3-25. All characters are coded in accordance with ASCII coding conventions.

[2] PACKED BINARY mode

Output data in this mode is output as one or two binary bytes, rather than as a character representation. This data output format is for high speed data transfer. Contents of output data, however, is less than that of ASCII mode. Output data in this mode includes status data for DISPLAY A and DISPLAY B, measurement range data as an 8-bit byte, and measurement data of DISPLAY A and DISPLAY B (not including unit and decimal point) as a 16-bit, 2's complement binary word. If the instrument is equipped with Option 002, comparison data (LOW, IN, HIGH) for L/C/|Z| and D/Q/ESR/G, and BIN number data can be output as an 8-bit byte. The displayed data is output as the equivalent decimal values of the resulting words. The output format is shown in Figure 3-26.

3-95. OUTPUT DATA FORMAT

3-96. The 4276A can output measurement data to a controller or can output data directly to an external "listener" device (i.e., printer). There are six Output Data Formats, F1 through F6. The contents of the output data for each format are listed in Table 3-15.

Note

In ADDRESSABLE MODE, only F1 through F4 can be set by HP-IB remote control. Output data can be in either ASCII mode or BINARY PACKED mode. Also, in ADDRESSABLE mode, bit switch settings have no relation to Output Data Format.

Note

In TALK ONLY mode, any Output Data Format, F1 through F6, can be set by HP-IB Control Switch settings (bit 1 through bit 3). Also, in TALK ONLY mode, data can be output in ASCII mode only.

Table 3-12. Remote Program Codes (Sheet 1 of 2)

| Item | Control | Program Code | Description | | | | | | | | | | | | | | | | |
|-----------------------|--|--|---|---|---|---|---|---|---|---|---|---|-----|-----|---------|---|-----|-----|---------|
| DISPLAY A Function | L C HIGH SPEED L HIGH SPEED C Z * | A1 A2* A3 A4 A5 | DISPLAY A and DISPLAY B combinations are listed in the table below: <table border="1" style="margin-left: 20px;"> <tr> <td style="text-align: center;">B</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td style="text-align: center;">A</td> <td style="text-align: center;">1</td> <td style="text-align: center;">2</td> <td style="text-align: center;">3</td> </tr> <tr> <td style="text-align: center;">1</td> <td style="text-align: center;">L-D</td> <td style="text-align: center;">L-Q</td> <td style="text-align: center;">L-ESR/G</td> </tr> <tr> <td style="text-align: center;">2</td> <td style="text-align: center;">C-D</td> <td style="text-align: center;">C-Q</td> <td style="text-align: center;">C-ESR/G</td> </tr> </table> | B | 1 | 2 | 3 | A | 1 | 2 | 3 | 1 | L-D | L-Q | L-ESR/G | 2 | C-D | C-Q | C-ESR/G |
| B | 1 | 2 | 3 | | | | | | | | | | | | | | | | |
| A | 1 | 2 | 3 | | | | | | | | | | | | | | | | |
| 1 | L-D | L-Q | L-ESR/G | | | | | | | | | | | | | | | | |
| 2 | C-D | C-Q | C-ESR/G | | | | | | | | | | | | | | | | |
| DISPLAY B Function | D Q ESR/G | B1 B2 B3* | * When DISPLAY A is set to Z , DISPLAY B is automatically set to θ . | | | | | | | | | | | | | | | | |
| CKT MODE | AUTO  | C1* C2 C3 | | | | | | | | | | | | | | | | | |
| MEAS SPEED | SLOW MED FAST | M1 M2* M3 | | | | | | | | | | | | | | | | | |
| Auto Range | OFF ON | U0 U1* | : Range is fixed. : Range is automatically selected. | | | | | | | | | | | | | | | | |
| LC Z Range | 100m Ω 10pF/1 Ω 100 μ H/100pF/10 Ω 1mH/1nF/100 Ω 10mH/10nF/1k Ω 100mH/100nF/10k Ω 1H/1 μ F/100k Ω 10H/10 μ F/1M Ω 100H/100 μ F/10M Ω 1kH/1mF 10mF | R1 R2 R3 R4 R5 R6 R7 R8 R9 RA RB | If the instrument is set to a range which cannot make the measurement, range is automatically reset to the nearest range capable of making the measurement. | | | | | | | | | | | | | | | | |
| Test Signal Level | LOW HIGH | V1 V2* | | | | | | | | | | | | | | | | | |
| Trigger Mode | INT MAN/EXT | T1* T2 | This code only sets the trigger mode; it does not trigger the instrument. | | | | | | | | | | | | | | | | |
| Execute | | EX | This code is used to trigger the instrument. | | | | | | | | | | | | | | | | |
| Self Test | OFF ON | S0* S1 | | | | | | | | | | | | | | | | | |
| Deviation Measurement | OFF ON | X0* X1 | | | | | | | | | | | | | | | | | |
| Zero Offset | OPEN SHORT | Z0 ZS | | | | | | | | | | | | | | | | | |

Table 3-12. Remote Program Codes (Sheet 2 of 2)

| Item | Control | Program Code | Description |
|---|---|---|--|
| Data Ready | OFF ON | D0 [*] D1 | If Data Ready is set to ON, an SRQ signal is output when the measurement is completed. |
| Comparator Enable | OFF ON | E0 [*] E1 | If the instrument is not equipped with Option 002, an error will result if E1 is sent via the HP-IB. |
| Comparator Run | OFF ON | G0 [*] G1 | |
| Comparator Limit | L/C/Z input D/Q/ESR/G input | L1 [*] L2 | |
| Comparator Bin Number | BIN1 BIN2 BIN3 BIN4 BIN5 BIN6 BIN7 BIN8 BIN9 | N1 [*] N2 N3 N4 N5 N6 N7 N8 N9 | These codes are used when setting L/C/ Z limits. |
| Comparator Limit Recall | | LR | Refer to paragraph 3-100. |
| Comparator Limit Erase | | ER | Comparator limits stored in all bins are cleared. |
| Output Data Abort | | DA | HP-IB output data are erased from the output buffer. |
| Output Data Format | Displays A/B or Comparator Displays A/B/Comparator Display A or Comparator Display A/Comparator | F1 [*] F2 F3 F4 | Refer to paragraph 3-96 and Table 3-16. |
| Learn Mode | | LN | Refer to paragraph 3-98. |
| Output Data Mode | ASCII BINARY | P0 [*] P1 | |
| <p>Note: [*] indicates an initial control setting (Refer to paragraph 3-38.)</p> | | | |

[1] ASCII mode (Set using HP-IB remote program code "P0")

Note

1 DISPLAY A/B

X X X ±NN.NNN E±NN , X X
 (1) (2) (3) (4) (5) (6) (7) (8)

When measurement error code, OF, UF, CF or blank, is indicated on DISPLAY A or DISPLAY B, value of DISPLAY A or DISPLAY B ((4) or (9)) is output as follows:

±N.NNNN E±NN CR LF
 (9) (10) (11)

OF (overflow) ±19999E+20
 UF (underflow) +00000E-20
 CF (change function)/
 blank +0000E-30

- (1) Measurement circuit mode
- (2) Status of DISPLAY A
- (3) Function of DISPLAY A
- (4) Value of DISPLAY A (position of decimal point is coincident with display)
- (5) Unit of DISPLAY A
- (6) Unit of DISPLAY A
- (7) Status of DISPLAY B
- (8) Function of DISPLAY B
- (9) Value of DISPLAY B (position of decimal point is coincident with display)
- (10) Unit of DISPLAY B
- (11) Data Terminator

Note

DISPLAY A and DISPLAY B ranges are expressed as an exponent as follows:

10⁻¹² (p) E-12
 10⁻⁹ (n) E-09
 10⁻⁶ (μ) E-06
 10⁻³ (m) E-03
 10⁰ E+00
 10³ (k) E+03
 10⁶ (M) E+06

2 COMPARATOR (Option 002 only)

X X N CR LF
 (1) (2) (3) (4)

Note

The data delimiter, bit switch 6 on the HP-IB Control Switch, is set at the factory to comma (,). This causes the instrument to output all data (DISPLAY A data, DISPLAY B data, and, if Comparator is used, Comparator data) as a continuous string. When the data delimiter is set to CR/LF, a carriage return and line feed signal is output after each field. This is useful when outputting data to certain peripherals, such as a printer.

- (1) Status of L/C | Z |
- (2) Status of D/Q/ESR/G
- (3) BIN number
- (4) Data Terminator

Note

The EOI signal is output with the LF signal.

Note

Status and function data of DISPLAY A and DISPLAY B, and status of Comparator are each represented as one alphabetic character, as listed in Table 3-14.

Figure 3-25. Data Output (ASCII).

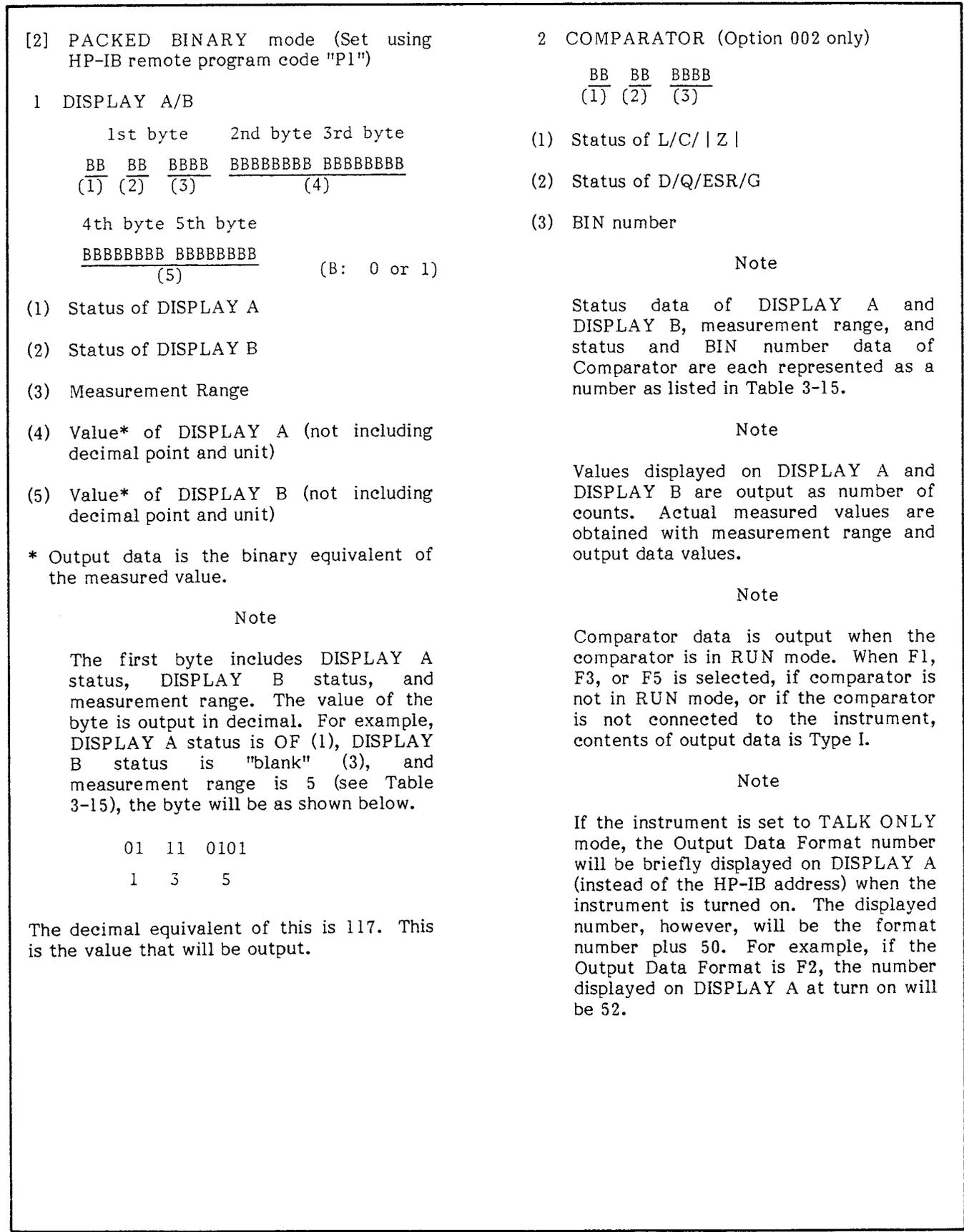


Figure 3-26. Data Output (Packed Binary).

Table 3-13. Data Output Codes for ASCII Mode

| Item | Information | Code |
|---|--|---|
| Circuit Mode |  | P |
| |  | S |
| Data Status of DISPLAY A/B | Normal Normal on Deviation Measurement Overflow Underflow Change Function Blank (used only for DISPLAY B) | N D O U C B |
| Function of DISPLAY A | L C HIGH SPEED L HIGH SPEED C Z | L C L C Z |
| Function of DISPLAY B | D Q ESR G θ HIGH SPEED L* ¹ HIGH SPEED C* ¹ | D Q R G T N |
| Data Status of L/C/ Z for Comparator | Bin IN HIGH LOW Embedded Undefined | I H L E* ² U* ³ |
| Data Status of D/Q/ESR/G for Comparator | Limit IN HIGH LOW Undefined | I H L U* ³ |
| Bin Number | Out of Bin BIN1 BIN2 BIN3 BIN4 BIN5 BIN6 BIN7 BIN8 BIN9 | 0 1 2 3 4 5 6 7 8 9 |
| <p>*¹ HIGH SPEED C and HIGH SPEED L have the same output codes.</p> <p>*² This code appears when the measurement value is between two continued bins.</p> <p>*³ This code appears when DISPLAY A or B indicates "CF" or blank.</p> | | |

Table 3-14. Data Output Codes for PACKED BINARY Mode

| Item | Information | Code |
|---|--------------------------|------|
| Data Status of DISPLAY A/B | Normal | 0 |
| | Overflow | 1 |
| | Underflow | 2 |
| | Change Function or Blank | 3 |
| Measurement Range | 100mΩ | 1 |
| | 10pF/1Ω | 2 |
| | 100μH/100pF/10Ω | 3 |
| | 1mH/1nF/100Ω | 4 |
| | 10mH/10nF/1kΩ | 5 |
| | 100mH/100nF/10kΩ | 6 |
| | 1H/1μF/100kΩ | 7 |
| | 10H/10μF/1MΩ | 8 |
| | 100H/100μF/10MΩ | 9 |
| | 1kHz/1mF | 10 |
| | 10mF | 11 |
| Data Status of L/C/ Z for Comparator | Bin IN | 0 |
| | HIGH | 1 |
| | LOW | 2 |
| | Embedded or Undefined | 3 |
| Data Status of D/Q/ESR/G for Comparator | Bin IN | 0 |
| | HIGH | 1 |
| | LOW | 2 |
| | Undefine | 3 |
| Bin Number | Out of Bin | 0 |
| | BIN1 | 1 |
| | BIN2 | 2 |
| | BIN3 | 3 |
| | BIN4 | 4 |
| | BIN5 | 5 |
| | BIN6 | 6 |
| | BIN7 | 7 |
| | BIN8 | 8 |
| | BIN9 | 9 |

Table 3-15. Data Output Format

| Data Output Format | | Output Data | | | Output Mode | |
|--------------------|----|-------------|-----------|------------|-------------|---------------|
| | | DISPLAY A | DISPLAY B | COMPARATOR | ASCII | BINARY PACKED |
| F1 | I | YES | YES | NO | YES | YES |
| | II | NO | NO | YES | | |
| F2 | I | YES | YES | YES | YES | YES |
| | II | YES | YES | NO | | |
| F3 | I | YES | NO | NO | YES | YES |
| | II | NO | NO | YES | | |
| F4 | I | YES | NO | NO | YES | YES |
| | II | YES | NO | YES | | |
| F5 | I | NO | YES | NO | YES | NO |
| | II | NO | NO | YES | | |
| F6 | I | NO | YES | NO | YES | NO |
| | II | NO | YES | YES | | |

I: Without the comparator (Model 16064A)

II: Using the comparator (Model 16064A).

Model 4276A

3-97. LEARN MODE DATA

3-98. All front panel settings and comparator key settings are output from the 4276A when the program code "LN" is used (refer to Figure 3-29). The data is output in the following format:

$$\frac{FRnnnnEN}{(1)} \quad \frac{An}{(2)} \quad \frac{Bn}{(3)} \quad \frac{Cn}{(4)} \quad \frac{Dn}{(5)} \quad \frac{Fn}{(6)} \quad \frac{Mn}{(7)} \quad \frac{Pn}{(8)}$$

$$\frac{Rn}{(9)} \quad \frac{Sn}{(10)} \quad \frac{Tn}{(11)} \quad \frac{Un}{(12)} \quad \frac{Vn}{(13)} \quad \frac{Xn}{(14)} \quad \frac{BI\pm nnnnEN}{(15)}$$

$$\frac{En}{(16)} \quad \frac{Gn}{(17)} \quad \frac{Ln}{(18)} \quad \frac{Nn}{(19)} \quad \frac{\textcircled{CR} \textcircled{LF}}{(20)}$$

- (1) Test Frequency Setting
- (2) A1 - A5: DISPLAY A Function
- (3) B1 - B3: DISPLAY B Function
- (4) C1 - C3: Circuit Mode
- (5) D0, D1: Data Ready
- (6) F1 - F4: Output Data Format
- (7) M1 - M3: Measurement Speed
- (8) P0, P1: Output Data Mode (ASCII or Packed Binary)
- (9) R1 - R9, RA, RB: LC | Z | Range
- (10) S0, S1: Self Test
- (11) T1, T2: Trigger Mode
- (12) U0, U1: Auto Range
- (13) V1, V2: Test Signal Level
- (14) X0, X1: Deviation Measurement
- (15) DC Bias Setting
- (16) E0, E1: Comparator Enable
- (17) G0, G1: Comparator Run
- (18) L1, L2: Comparator Limit Input
- (19) N1 - N9: Comparator Bin Number for L/C/|Z|
- (20) Data Terminator

Note

DC Bias data is not output when DC Bias option (OPTION 001) is not installed. Similarly, when the comparator (OPTION 002) is not installed, comparator data is not output.

Note

Don't open the UNKNOWN terminals no test fixture or test leads when LEARN mode data is output in AUTO range. If so, measurement range is not fixed in some cases. there is no problem when a test fixture is connected to the UNKNOWN terminals or when measurement range is set to MANUAL mode.

3-99. RECALL COMPARATOR LIMIT DATA

3-100. Low and high bin limits can be output from the 4276A when the program code "LR" is used (refer to Figure 3-31). The L/C/|Z| limits for the designated bin are output when code "L1" is used, D/Q/ESR/G limits are output. The data is output in the following format:

$$\frac{LLXX.XXXEN}{(1)} \quad \frac{LHXX.XXXEN}{(2)} \quad \frac{\textcircled{CR} \textcircled{LF}}{(3)}$$

- (1) Value of Low Limit (position of decimal point is coincident with display)
- (2) Value of High Limit (position of decimal point is coincident with display)
- (3) Data Terminator

3-101. SERVICE REQUEST STATUS BYTE

3-102. The 4276A outputs an RQS (Request Service) signal whenever it is set to one of the five possible service request states. Figure 3-27 shows the contents of the Status Byte.

SECTION III

| Bit | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
|---------|---|-----|---|-------|------------------|---------------------------|--------------|------------|
| Content | | RQS | | Error | Trigger Too Fast | Zero Offset Self Test End | Syntax Error | Data Ready |

Bit 7 (RQS) indicates whether or not a service request exists. Bits 6 and 8 are always zero (0). Bits 1 through 5 identify the type of service request. Following are the service request states of the 4276A:

- (1) Bit 1: This bit is set when measurement data is ready for output.
- (2) Bit 2: This bit is set when the remote program contains a syntax error.
- (3) Bit 3: This bit is set when Zero Offset or Self Test is completed under remote control.
- (4) Bit 4: This bit is set when the 4276A is externally triggered before the measurement has been completed.
- (5) Bit 5: 1 This bit is set when the 4276A has one of the following operation errors:
OFF, E10, E11, E13, E14, E15, E16, E17, E18, E19
- 2 If Self Test is set to ON, this bit is set when the instrument fails Self Test.
E37 - E39, E40 - E45

Figure 3-27. Status Byte for the 4276A.

Model 4276A

3-103. PROGRAMMING GUIDE FOR 4276A

3-104. Sample programs that can be run on the HP-85, 9835A/B, 9845B, 9826A, or 9836A are given in Figures 3-28 through 3-31. These programs are listed in Table 3-16.

Note

Controller-specific HP-IB programming information is given in the controller's programming manual.

Note

Following equipment is required to run the sample programs:

- (1) 4276A LCZ Meter
 - (2) HP-85 Personal Computer
00085-15003 I/O ROM
 - (3) 82937A HP-IB INTERFACE
- or
- (2) 9835A/B Desktop Computer
98332A I/O ROM
 - (3) 98034A HP-IB INTERFACE
CARD
- or
- (2) 9826A Desktop Computer
 - (3) 10833B HP-IB INTERFACE CABLE
- or
- (2) 9836A Desktop Computer
 - (3) 10833B HP-IB INTERFACE CABLE

Table 3-16. Sample Programs Using HP-85

| Sample Program | Figure | Description |
|----------------|--------|--|
| 1 | 3-28 | Remote control and data output program |
| 2 | 3-29 | How to use remote program code "LN." |
| 3 | 3-30 | How to input low and high bin limits for the Comparator. |
| 4 | 3-31 | How to use remote program code "LR." |

SECTION III

Sample Program 1

Description:

This program has three capabilities:

- (1) Control of the 4276A via the HP-IB
- (2) Trigger of the 4276A via the HP-IB
- (3) Data output from the 4276A via the HP-IB

Program:

```
10  REMOTE 717
20  CLEAR 717
30  DIM A$[50]
40  OUTPUT 717; "A2B1T2P0F1"
           (1)(2)      (3)
50  OUTPUT 717; "FR10EN"
           (4)
60  OUTPUT 717; "EX"
           (5)
70  ENTER 717; A$
80  DISP A$
90  PRINT A$
100 END
```

- (1) HP-IB INTERFACE Select Code (82937A or 98034A)
- (2) HP-IB Address of the 4276A
- (3) Program codes for the 4276A (refer to Table 3-13)
- (4) Program codes for parameter setting of the 4276A (refer to paragraph 3-96)
- (5) This is equivalent to: TRIGGER 717

Figure 3-28. Sample Program 1 (Sheet 1 of 2).

If program code "P1" is used, refer to the following program :

Program :

```

10  REMOTE 717
20  CLEAR 717
30  OUTPUT 717 ; " A2B1T2P1F1 "
40  OUTPUT 717 ; " EX "
50  ENTER 717 USING "%, B, W, W" ; A, B, C
      (1) (2) (3) (3)

60  DISP A;B;C
70  PRINT A;B;C
80  END

```

- (1) ENTER terminator. "#" can also be used.
- (2) Specifier for entering one byte (8-bit) of binary data
- (3) Specifier for entering two bytes (16-bit) of binary data

Figure 3-28. Sample Program 1 (Sheet 2 of 2).

Sample Program 2

Description:

The remote program code "LN" can be used to read the front panel control settings and comparator settings. This program shows how to use "LN."

Program :

```

10  REMOTE 717
20  CLEAR 717
30  DIM A$(60)
40  OUTPUT 717 ; "LN"
50  ENTER 717 ;A$
60  DISP A$
70  PRINT A$
80  END

```

Figure 3-29. Sample Program 2.

SECTION III

Sample Program 3

Description:

This program shows how to input low and high bin limits via the HP-IB when the instrument is equipped with Option 002.

Program:

```
10  REMOTE 717
20  CLEAR 717
30  DIM A$(50)
40  OUTPUT 717;" A2B1R4T2P0F2 "
      (1)
50  OUTPUT 717;" FR10EN "
60  OUTPUT 717;" E1G0ER "
      (2)
70  OUTPUT 717;" L1N1LL. 995ENLH. 998EN "
      (2)      (3)
80  OUTPUT 717;" N2LL1 ENLH1. 1EN "
90  OUTPUT 717;" N3LL 1.1001ENLH1.2EN "
100 OUTPUT 717;" L2LLOENLH. 001EN "
110 OUTPUT 717;" G1 "
120 OUTPUT 717;" EX "
130 ENTER 717;A$
140 DISP A$
150 PRINT A$
160 END
```

- (1) Measurement range must be set.
- (2) Program codes for comparator setting
- (3) Program codes for inputting low and high bin limits

Figure 3-30. Sample Program 3.

Sample Program 4

Description

The remote program code "LR" can be used to recall the high and low limits for each bin. This program shows how to use "LR."

Program :

```
10  REMOTE 717
20  DIM A$(30)
30  OUTPUT 717 ; "E1G0"
40  FOR I = 1 TO 9
50  OUTPUT 717 ; "L1N";I, "LR"
60  ENTER 717 ; A$
70  PRINT A$
80  NEXT I
90  OUTPUT 717 ; "L2LR"
100 ENTER 717 ; A$
110 PRINT A$
120 END
```

Figure 3-31. Sample Program 4.

SECTION III

3-105. OPTIONS

3-106. Options are standard modifications to the instrument that implement user's special requirements for minor functional changes. Operating instructions for the 4276A's options (except rack mount and handle installation kit options) and associated information are described in the following paragraphs.

3-107. Two options are available, as listed in the following tables:

| Option No. | Option |
|------------|------------------------------|
| 001 | Internal Dc Bias |
| 002 | Comparator/Handler Interface |

Option contents are as follows:

| Option NO. | Contents |
|------------|------------------------|
| 001 | HP Part No.04276-66522 |
| 002 | HP 16064A |

Model 4276A

3-108. OPTION 001 INTERNAL DC BIAS (-40V to +40V)

3-109. Option 001 adds an internal dc bias supply variable from .00 volts to ± 40.0 volts. The dc bias voltage can be controlled manually from the frontpanel or remotely via the HP-IB. Manual control is described in Figure 3-32. For dc bias applications under HP-IB control, refer to Figure 3-33. The internal dc bias source has two ranges and a maximum resolution of 10mV. Refer to Table 3-17. Output from the bias source is automatically set to 0V each time the instrument is turned on or when the CLEAR command is sent via the HP-IB. DC bias voltage is applied to the DUT only when the DC BIAS select switch on the rear panel is set to INT and the DC BIAS switch on the front panel is set to ON. If the DC BIAS switch is set to OFF, OFF will be briefly displayed on the FREQUENCY/DC BIAS display each time a new bias voltage is set. The dc bias voltage actually applied to the DUT depends on the impedance of the DUT and in most cases will be less than the voltage value displayed on the FREQUENCY/DC BIAS display. By connecting a DVM or an oscilloscope to the EXT INPUT/INT MONITOR connector on the rear panel, the dc bias voltage actually applied across the DUT can be monitored. Refer to Figure 3-34.

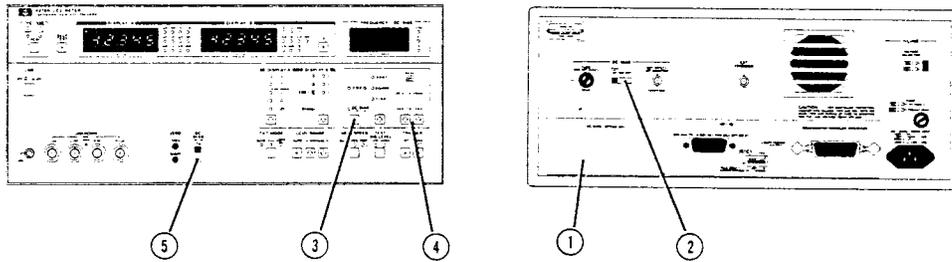
Table 3-17. Bias Voltage Resolution

| Bias Voltage Range | Resolution |
|-----------------------------|------------|
| 0V $\sim\pm$ 9.99 V | 10 mV |
| \pm 10.0V $\sim\pm$ 40.0V | 100 mV |

Note

For the option 001 operation, set the DC BIAS select switch on the rear-panel to INT.

OPTION 001 INTERNAL DC BIAS OPERATION



1. Set the DC BIAS select switch (2) to INT.
 2. Connect the 16047A Test Fixture to the UNKNOWN terminals.
- Note
- Any of the test fixtures and test leads listed in Table 1-3 can be used for measurements requiring dc bias.
3. Turn on the 4276A.
 4. Perform OPEN and SHORT Zero Offset adjustments as described in paragraph 3-48.
 5. Set the instrument's front panel controls as appropriate for the desired measurement.
 6. Press the FREQ/DC BIAS select key (3). The DC BIAS lamp will come on.
 7. Set the desired voltage by pressing the appropriate FREQ/DC BIAS control key (4). The voltage value will be displayed on the FREQUENCY/DC BIAS display.

Note

OFF will be briefly displayed on the FREQUENCY/DC BIAS display when the FREQ/DC BIAS control key is released, if the DC BIAS ON/OFF switch (5) is set to OFF.

8. Connect the DUT to the test fixture.

CAUTION

DO NOT CONNECT A CHARGED DUT TO THE TEST FIXTURE. DOING SO MAY DAMAGE THE INSTRUMENT.

9. Set the DC BIAS switch (5) to ON.
10. If you are measuring a capacitive DUT, allow sufficient time for the DUT to charge up to the applied voltage.
11. Read the measured values displayed on DISPLAY A and DISPLAY B.
12. Set the DC BIAS switch (5) to OFF.
13. Wait until the voltage across the DUT return to 0V.
14. Remove the DUT from the test fixture.

Note

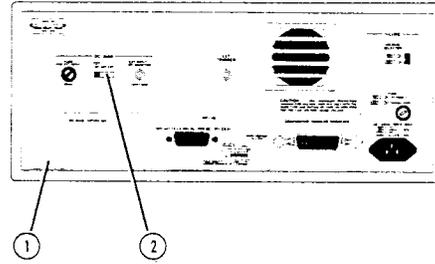
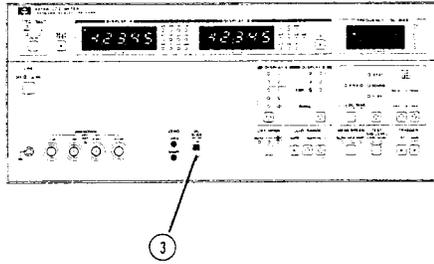
For reasons of safety and measurement accuracy, the voltage actually applied to the DUT should be monitored. Refer to Figure 3-34.

Note

When the DC BIAS switch on the front panel has been set to ON and the desired bias voltage is entered, the instrument automatically takes a wait time of approximately 0.8 seconds before outputting the bias voltage (after completion of the bias data input). Accordingly, it takes approximately (0.8 seconds + bias settling time) for the bias voltage to be applied to the DUT as well as to be settled after the bias data has been set. For the bias settling time, refer to Figure 1-2 Supplemental Performance Characteristics.

Figure 3-32. Option 001 Internal DC Bias Operation.

OPTION 001 INTERNAL DC BIAS HP-IB OPERATION



[HP-IB Operation]

The following procedure is an example of dc bias remote control via the HP-IB.

1. Set the DC BIAS select switch ② to INT.
2. Connect the 16047A Test Fixture to the UNKNOWN terminals.

Note

Any of the test fixtures and test leads listed in Table 1-3 can be used for measurements requiring dc bias.

3. Turn on the 4276A.
4. Perform OPEN and SHORT Zero Offset adjustments as described in paragraph 3-48.
5. Set the DC BIAS switch ③ to ON.

Note

The dc bias voltage is automatically set to 0V each time the instrument is turned on.

6. Set the front panel control via the HP-IB.

* Example of setting the instrument for a C-D measurement at 10kHz, external trigger.

```
CLEAR 717
OUTPUT 717; "A2B1FR10ENF1T2"
```

7. Connect the DUT to the test fixture.
8. Set the desired dc bias voltage via the HP-IB.

* Example of setting a dc bias voltage of +10V.

```
OUTPUT 717; "BI10EN"
```

9. Wait until the dc bias voltage settles.

* Example of programming a 2-second wait.

```
WAIT 2000
```

10. Trigger the instrument via the HP-IB.

```
OUTPUT 717; "EX"
or
TRIGGER 717
```

11. Read and print the measured values.

```
ENTER 717; A, B
PRINT A, B
```

12. Set the bias voltage to 0V via the HP-IB.

```
OUTPUT 717; "BI 0EN"
```

13. Wait until the dc bias voltage returns to 0V.

* Example of programming a 1-second wait.

```
WAIT 1000
```

14. Remove the DUT from the test fixture.

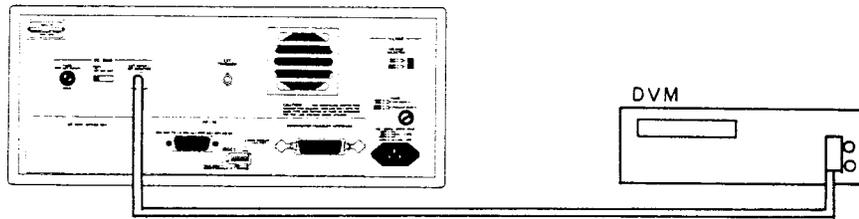
Note

The above remote programming examples can be used on the HP Model 85 (with 00085-15003 I/O ROM), Model 9835A, Model 9845B/C, Model 9826A, and Model 9836A.

In the above examples, HP-IB address 17 was used.

Figure 3-33. Option 001 Internal DC Bias HP-IB Operation.

INTERNAL DC BIAS VOLTAGE MONITOR



Note

The internal dc bias voltage is monitored by a DVM or an oscilloscope at the EXT INPUT/INT MONITOR connector on the rear panel.

Note

The dc bias voltage monitored at the EXT INPUT/INT MONITOR connector may contain a small ac component.

When the DUT impedance is higher than 100k Ω , the monitored voltage is equal to the dc voltage source voltage, and to the voltage applied to the DUT. These voltages, however, are different when the DUT impedance is less than 100k Ω . The following paragraph describes how to measure the actual bias voltage across the DUT.

1. $R_1/R_2/R_L$ Detection (See Figure A.)

- Set the TEST SIG LEVEL to LOW.
- Set the LC |Z| range so that the range resistor value will be 100 Ω . Refer to Figure 3-16.
- Set the DC BIAS voltage to +5V on the FREQUENCY/DC BIAS display.
- Connect nothing to the test fixture.
- Set the DC BIAS switch on the front panel to ON.
- Measure the monitor voltage (V_0) at the EXT INPUT/INT MONITOR connector.
- Connect a reference resistor (R_0) (e.g., 100 $\Omega \pm 1\%$) to the test fixture.
- Measure the dc voltages at the HIGH and LOW terminals of the test fixture and at the EXT INPUT/INT MONITOR connector (V_H , V_L , and V_K).

Connect the LOW terminal of the DVM or the oscilloscope to the GUARD terminal of the instrument.

- Calculate the resistances, R_1 , R_2 , and R_L , using the following equations:

$$R_1 = (V_0 - V_K) \cdot R / (V_H - V_L)$$

$$R_2 = (V_K - V_H) \cdot R / (V_H - V_L)$$

$$R_L = V_L \cdot R_0 / (V_H - V_L)$$

2. Actual Bias Voltage/Current Measurement

- Connect nothing to the test fixture.
- Measure the monitor voltage (V_0).
- Connect the desired sample to the test fixture.
- Measure the monitor voltage (V_M).
- Calculate the actual voltage applied to the DUT (V) or the actual current through the DUT (I) using the following equations:

$$I = (V_0 - V_M) / R_1$$

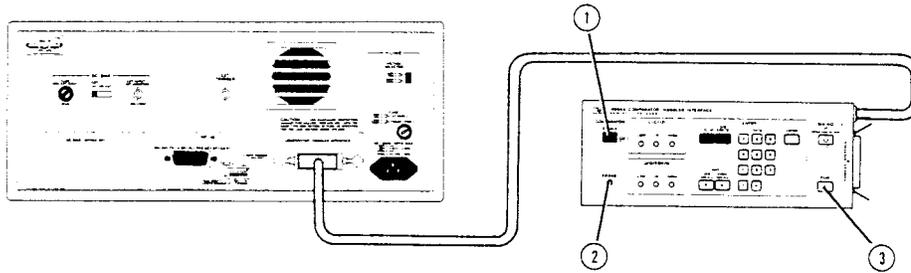
$$V = V_0 - (R_1 + R_2 + R_L) \cdot I$$

Note

Repeat step 2 each time the DUT is changed since the monitor voltage (V_M) depends on the DUT impedance.

Figure 3-34. Internal DC Bias Voltage Monitor (Sheet 1 of 2).

OPTION 002 COMPARATOR OPERATION



1. Connect the Model 16064A COMPARATOR/HANDLER INTERFACE to the COMPARATOR/HANDLER INTERFACE connector on the 4276A's rear-panel.
2. Connect the desired test fixture to UNKNOWN terminals.
3. Turn on the instrument.
4. Perform OPEN and SHORT Zero Offset adjustments as described in paragraph 3-48.
5. Set the front panel controls as appropriate for the desired measurement.
6. Press the ENABLE key on the 16064A. The LED lamp at the center of the key should come on.

Note

If E16 is displayed on DISPLAY A, press the ERASE button on the 16064A to erase previously stored limits.

7. Enter the high/low limits for L/C/|Z| or D/Q/ESR/G as described in Figure 3-36.
8. Press the RUN key on the 16064A. The comparator will then begin comparing all measured values with the high/low limits entered in step 7. The appropriate LED lamps--LOW, IN, HIGH--will be lit and the number of the bin whose high/low limits fit the measured values will be displayed on the FREQUENCY/DC BIAS display.

Example:

If the bin limits listed in Tables A and B are entered, the measured values listed in Table C will cause the comparison results shown in Table D.

Table A. Limits for L/C/|Z|

| BIN No. | LOW LIMIT | HIGH LIMIT |
|---------|-----------|------------|
| 1 | 1 nF | 1.1 nF |
| 2 | 1.1 nF | 1.2 nF |
| 3 | 1.2 nF | 1.3 nF |
| 4 | 1.3 nF | 1.4 nF |
| 5 | 1.4 nF | 1.5 nF |
| 6 | 2 nF | 2.5 nF |
| 7 | 2.5 nF | 3 nF |

Figure 3-35. Option 002 Comparator Operation (Sheet 1 of 2).

Table B. Limits for D/Q/ESR/G

| LOW LIMIT | HIGH LIMIT |
|-----------|------------|
| .01 | .05 |

Table C. Measured Values

| Sample | Measured Value | | Sample | Measured Value | |
|--------|----------------|---------|--------|----------------|---------|
| 1 | C | 1.22 nF | 6 | C | 1.1 nF |
| | D | .013 | | D | .02 |
| 2 | C | 1.08 nF | 7 | C | 1.18 nF |
| | D | .005 | | D | .071 |
| 3 | C | .8 nF | 8 | C | 4.1 nF |
| | D | .025 | | D | .033 |
| 4 | C | 2.75 nF | 9 | C | 1.5 nF |
| | D | .06 | | D | .029 |
| 5 | C | .95 nF | 10 | C | 1.72 nF |
| | D | .055 | | D | .025 |

Note

LOW and HIGH limits are inclusive; that is, if the measured value is exactly equal to the LOW or HIGH limit of a bin, the measured value fits the limits for that bin. Also, if a measured value fits the limits of more than one bin (bin limits overlap), the comparator selects the bin with the lower number. An example follows.

Bin 1: 100pF to 200pF
 Bin 2: 150pF to 250pF
 Measured Value: 190pF
 Selected Bin: Bin 1

Table D. Comparison Results

| Sample | L/C/ Z Lamp | | | D/Q ESR Lamp | | | FREQUENCY/ DC BIAS Display |
|--------|-------------|----|------|--------------|----|------|----------------------------|
| | LOW | IN | HIGH | LOW | IN | HIGH | |
| 1 | o | • | o | o | • | o | 3 |
| 2 | o | • | o | • | o | o | 0 |
| 3 | • | o | o | o | • | o | 0 |
| 4 | o | • | o | o | o | • | 0 |
| 5 | • | o | o | o | o | • | 0 |
| 6 | o | • | o | o | • | o | 1 |
| 7 | o | • | o | o | o | • | 0 |
| 8 | o | o | • | o | • | o | 0 |
| 9 | o | • | o | o | • | o | 5 |
| 10 | • | o | • | o | • | o | 0 |

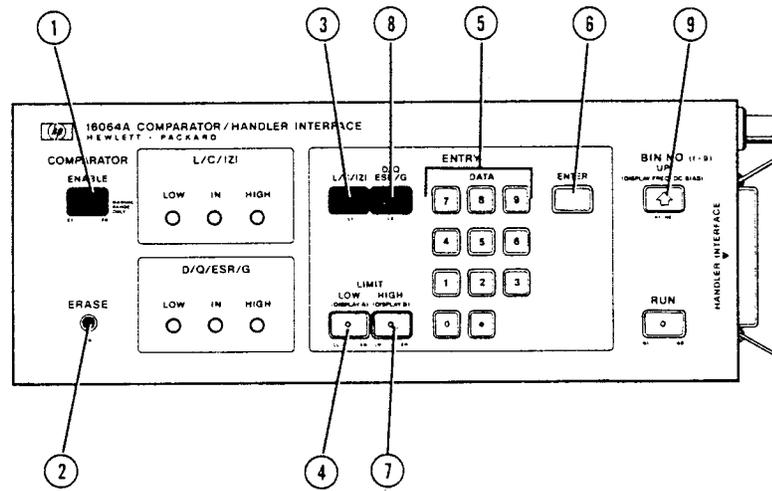
Note

If the LOW/HIGH limits for D/Q/ESR/G are not entered, or when the instrument is set to HIGH SPEED L or HIGH SPEED C, the IN lamp for D/Q/ESR/G will be always lit. D/Q/ESR/G comparison is not performed, however.

Figure 3-35. Option 002 Comparator Operation (Sheet 2 of 2).

SECTION III

COMPARATOR LIMIT SETTING



1. Press the ENABLE key ①. The LED lamp at the center of the key should come on.
2. Press the ERASE button ② to erase previously stored limits. One (1) will be displayed on the FREQUENCY/DC BIAS display.

[L/C/|Z| Limit Entry]

3. Press the L/C/|Z| key ③.
4. Press the LIMIT LOW key ④.
5. Key in the desired LOW limit using the DATA keys ⑤. The LOW limit value will be displayed on DISPLAY A.
6. Press the ENTER key ⑥. The LOW limit will be stored for bin 1. Also, the maximum allowable value that can be entered for the HIGH limit on the present LC|Z| RANGE will be displayed on DISPLAY B.

Note

If the LOW or HIGH limit is higher than the full scale value of the existing LC|Z| RANGE, E18 will be briefly displayed on DISPLAY A when the ENTER key is pressed. Re-enter the limits correctly.

7. Press the LIMIT HIGH key ⑦.

8. Key in the desired HIGH limit using the DATA keys ⑤. The HIGH limit value will be displayed on DISPLAY B.

9. Press the ENTER key ⑥. The HIGH limit will be stored for bin 1.

10. Press the BIN NO UP key ⑨. Two (2) will be displayed on the FREQUENCY/DC BIAS display.

11. Repeat steps 4 through 9 to enter the LOW and HIGH limits for bin 2.

12. Repeat steps 10 and 11 for bins 3 through 9.

[D/Q/ESR/G Limit Entry]

13. Press the D/Q/ESR/G key ⑧.

Note

When D/Q/ESR/G limits are being entered, no bin number is displayed on the FREQUENCY/DC BIAS display.

14. Press the LIMIT LOW key ④.

15. Key in the desired LOW limit using the DATA keys ⑤. The LOW limit value will be displayed on DISPLAY A.

16. Press the ENTER key ⑥. The LOW limit will be stored. Also, the maximum allowable value that can be entered for the HIGH limit will be displayed on DISPLAY B.

Figure 3-36. Comparator Limit Setting (Sheet 1 of 2).

Note

If the LOW or HIGH limit is higher than the full scale value of the existing DISPLAY B range, E18 will be briefly displayed on DISPLAY A when the ENTER key is pressed. Re-enter the limits correctly.

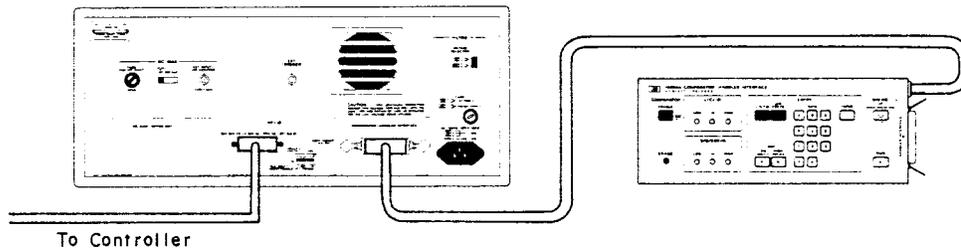
17. Press the LIMIT HIGH key ①.
18. Key in the desired HIGH limit using the DATA keys ③. The HIGH limit value will be displayed on DISPLAY B.
19. Press the ENTER Key.

Note

Press the ERASE button ②, erases the high/low limits of all bins.

Figure 3-36. Comparator Limit Setting (Sheet 2 of 2).

OPTION 002 COMPARATOR HP-IB OPERATION



[HP-IB OPERATION]

1. Connect the Model 16064A COMPARATOR/HANDLER INTERFACE to the COMPARATOR/HANDLER INTERFACE connector on the 4276A's rear-panel.
2. Connect the desired test fixture to the UNKNOWN terminals.
3. Turn on the instrument.
4. Perform OPEN and SHORT Zero Offset Adjustments.
5. Set the front panel controls as appropriate for the desired measurement and enable the 16064A via the HP-IB.

* Example of setting C-D measurement, 1nF range, and 10kHz test frequency

```
DIM A${1},B${1}
CLEAR 717
OUTPUT 717;"A2B1R4T2FR10EN"
OUTPUT 717;"E1ER"
```

6. Enter the LOW/HIGH limits for L/C/|Z| via the HP-IB.

* Example of setting a low limit of .950nF and a high limit = 1.1nF

```
OUTPUT 717;"LL.95ENLH1.1EN"
```

If necessary, enter the limits for the next bin (Bin 2).

* Example of setting bin 2's low limit to 1.1001nF and high limit to 1.2nF

```
OUTPUT 717;"N2"
OUTPUT 717;"LL1.1001ENLH1.2EN"
```

Note

The same setting can be made by the following program :

```
OUTPUT 717;"N2"
OUTPUT 717;"LH1.2EN"
```

7. Enter the limits for D/Q/ESR/G via the HP-IB.

* Example of setting a low limit of .0000 and a high limit of .005

```
OUTPUT 717;"L2"
OUTPUT 717;"LL0ENLH.005EN"
```

Note

The same setting can be made by the following program :

```
OUTPUT 717;"L2"
OUTPUT 717;"LH.005EN"
```

Note

Comparator operations can be done without high/low limits for D/Q/ESR/G.

Figure 3-37. Option 002 Comparator HP-IB Operation (Sheet 1 of 2).

8. Start the comparator operation by HP-IB program.

* Example of starting the comparator operation:

```
OUTPUT 717;"G1"
```

9. Connect the DUT to the test fixture.

10. Trigger the instrument via the HP-IB.

* Example of triggering the instrument:

```
OUTPUT 717;"EX"
```

or

```
TRIGGER 717
```

If necessary, read the comparison results via the HP-IB.

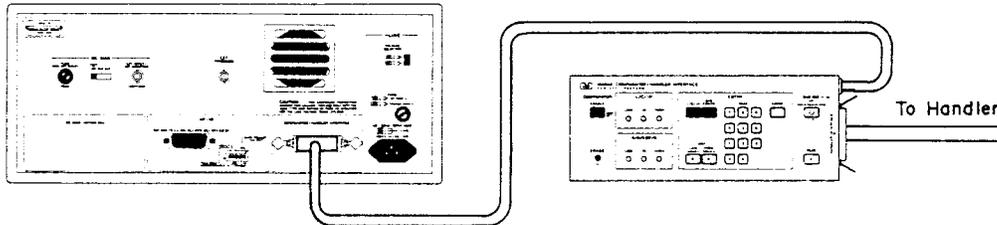
```
ENTER 717;A$,B$,N  
PRINT A$,B$,N
```

Note

The HP-IB address code in the above examples is 17 (10001).

Figure 3-37. Option 002 Comparator HP-IB Operation (Sheet 2 of 2).

OPTION 002 HANDLER INTERFACE OPERATION



The 16064A outputs four types of signals to the component handler.

- (1) Comparison result signals (LCHI, LCIN, LCLO, DQHI, DQIN, DQLO)
- (2) Bin number signals (BIN1 ... BIN9, OUT-OF-BIN)
- (3) DUT change signal (INDEX)
- (4) Comparison complete signal (EOM)

Type (1) signals correspond to the LOW/IN/HIGH LED lamps on the 16064A keyboard. Type (1) signals are divided into two groups of three. When the signal line corresponding to the lit LED lamp goes LOW, the other signal lines in that group stay HIGH.

Type (2) signals correspond to the bin numbers displayed on the FREQUENCY/DC BIAS display. When the signal line corresponding to the displayed bin number goes LOW, the other signal lines stay HIGH.

The type (3) signal, INDEX, goes LOW when the 4276A has completed the analog portion of the measurement. The DUT can be disconnected from the measurement terminals and the next one can be connected. Comparison results, however, are not yet valid.

The type (4) signal, EOM, goes LOW when the 4276A has completed the measurement and the comparator has made a judgement. Comparison results are now valid.

All signals are negative true, and all are from TTL open-collector outputs. Pull-up resistors are installed. TTL voltage levels or higher voltages (up to 30V) are possible by changing a few jumper settings inside the 16064A. Refer to the 16064A Operating Note for details.

Signals sent from the external component handler to the 16064A are a trigger signal (EXT TRIG) that starts measurement and a key lock signal (KEY LOCK) that disables all control keys during comparator operation. To trigger the 4276A, apply a LOW signal (at least 100 μ s duration) to the EXT TRIG line. To disable the control keys of the 4276A and 16064A, apply a LOW signal to the KEY LOCK line.

Note

The INDEX and KEY LOCK signals are not mandatory for comparator/handler interface applications.

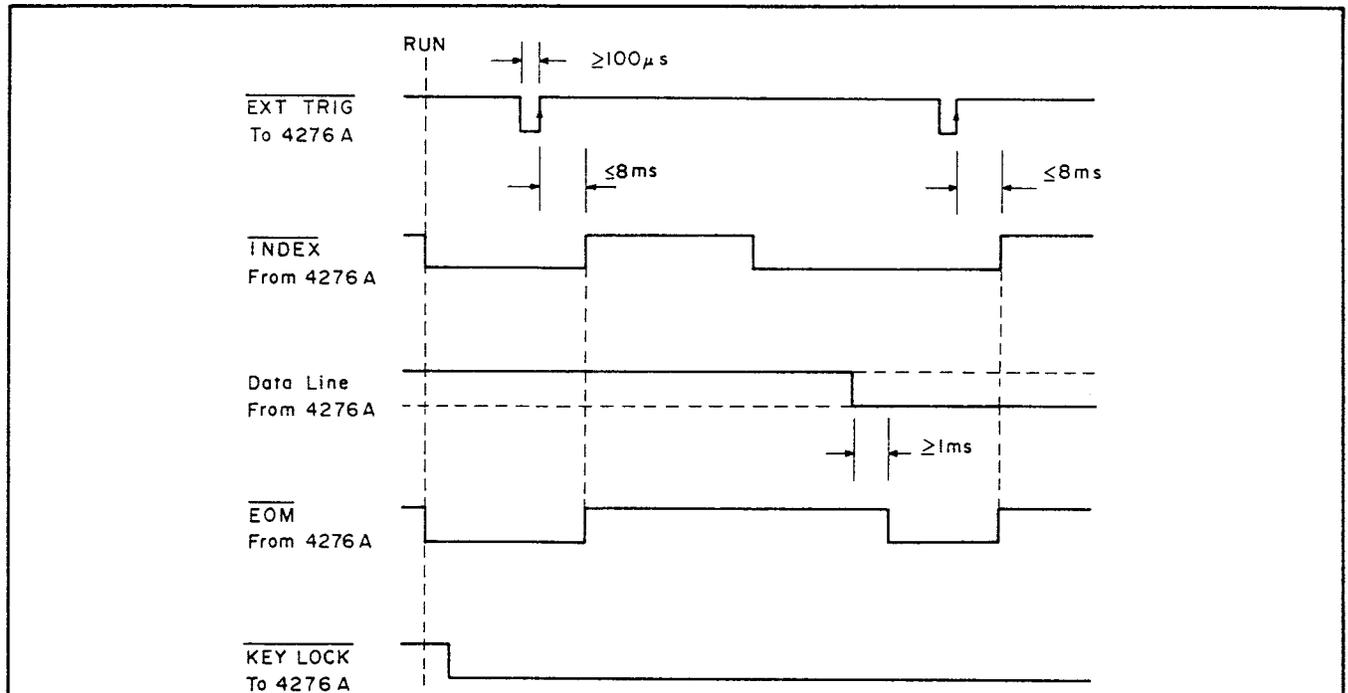
Note

More information on the Option 002 Handler Interface is given in the 16064A Operating Note.

Note

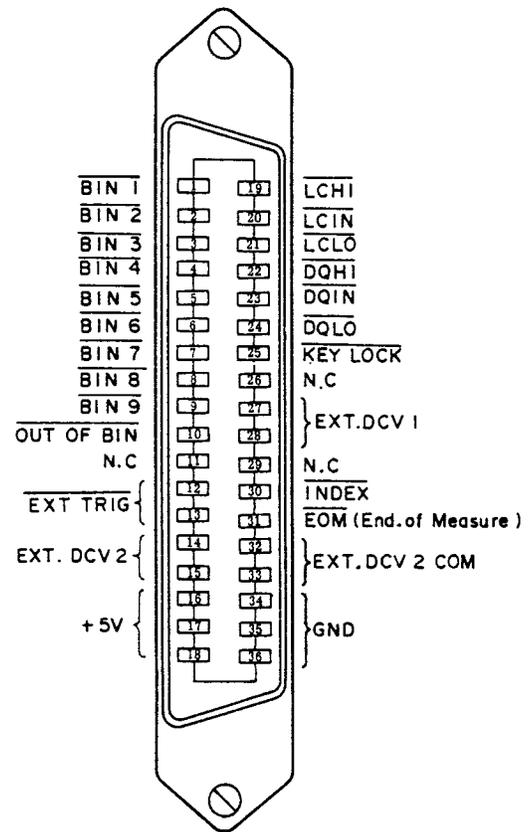
When the RUN key on the 16064A is pressed to start the comparator's operation, the OUT OF BIN line, pin 10 of the Handler Interface connector, is initially set to its active level (LOW).

Figure 3-38. Option 002 Handler Interface Operation (Sheet 1 of 2).



PIN ASSIGNMENTS FOR THE HANDLER INTERFACE CONNECTOR (HP 16064A)

| PIN No. | Signal | PIN No. | Signal |
|---------|-------------|---------|--------------|
| 1 | BIN 1 | 19 | LC Z HI |
| 2 | BIN 2 | 20 | LC Z IN |
| 3 | BIN 3 | 21 | LC Z LO |
| 4 | BIN 4 | 22 | DQESRG HI |
| 5 | BIN 5 | 23 | DQESRG IN |
| 6 | BIN 6 | 24 | DQESRG LO |
| 7 | BIN 7 | 25 | KEY LOCK* |
| 8 | BIN 8 | 26 | NC |
| 9 | BIN 9 | 27 | EXT DCV 1* |
| 10 | OUT OF BINS | 28 | EXT DCV 1* |
| 11 | NC | 29 | NC |
| 12 | EXT TRIG* | 30 | INDEX |
| 13 | EXT TRIG* | 31 | EOM |
| 14 | EXT DCV 2* | 32 | EXT DCV COM* |
| 15 | EXT DCV 2* | 33 | EXT DCV COM* |
| 16 | +5V | 34 | GROUND |
| 17 | +5V | 35 | GROUND |
| 18 | +5V | 36 | GROUND |



*: Externally Applied Signals

Figure 3-38. Option 002 Handler Interface Operation (Sheet 2 of 2).

SECTION III

3-114. POWER FAILURE MONITOR SIGNAL

3-115. If the instrument experiences a transient power failure such that the output voltage from the +5V power supply on the A1 board drops below +4.8V, all measurement circuits will be reset when the voltage returns to normal. Usually the duration of a transient power failure and the time required for the reset operation are so short that the operator may not be aware that the instrument has experienced a power failure. In most applications, this is not a problem, because the instrument's continuous memory function restores all settings (except the DC bias setting on option 001 instruments) after the reset operation. In some applications, though, a transient power failure, however brief, can adversely affect measurement results. In such applications it is important to know whether a power failure has occurred.

The 4276A is equipped with a power failure monitor signal (PWF) which can be used to inform the operator or peripherals of a transient power failure. The PWF signal is of the open collector type, and therefore requires an external (user-supplied) voltage source (+5V max.) and a pull-up resistor. Also, two wires must be connected to a jumper inside the 4276A and brought out through a hole in the rear panel. Complete instructions are given in paragraph 2-31.

Number of Display Digits

The number of display digits on DISPLAY A/B for C-D measurement, C-ESR/G measurement, L-D measurement, L-ESR/G measurement, and $|Z| - \theta$ measurement is listed in Tables 1 through 5. The number of display digits for a Q measurement depends on the D value and is listed in Table 6.

Note

Tables 1 through 5 are valid under the following conditions:

- (1) Circuit Mode: AUTO
- (2) Test Signal Level: HIGH

Note

When the test signal level is set to LOW, the number of display digits is one less than the number of display digits when the test signal level is set to HIGH.

Note

Alphabetic characters used in the Tables represent the number of display digits as follows:

| Symbol | Display |
|--------|---------|
| A | 888888 |
| B | 8888 |
| C | 888.0 |
| D | 88.00 |

Figure 3-39. Number of Display Digits (Sheet 1 of 13).

Table 1. C-D Measurement

| C Range | Test Frequency | | | | | | | |
|-------------|--|-------|-------|------|------|------|-------|-------|
| | 100Hz | 200Hz | 500Hz | 1kHz | 2kHz | 5kHz | 10kHz | 20kHz |
| 10mF | See Graph 1 /See Graph 2 See Graph 1 /See Graph 2 | | | | | | | |
| 1mF | | | | | | | | |
| 100 μ F | | | | | | | | |
| 10 μ F | A / A·B See Graph 7 /See Graph 8 | | | | | | | |
| 1 μ F | | | | | | | | |
| 100nF | B / B·C See Graph 7 /See Graph 8 | | | | | | | |
| 10nF | | | | | | | | |
| 1nF | | | | | | | | |
| 100pF | [Shaded Area] | | | | | | | |
| 10pF | | | | | | | | |

Alphabetic characters used in Table 1 represent:

Number of C Display Digits(*/**)
Number of D Display Digits(*/**)

- * : MED measurement speed mode.
- ** : SLOW or FAST measurement speed mode (SLOW·FAST).

Figure 3-39. Number of Display Digits (Sheet 2 of 13).

Table 2. C-ESR/G Measurement

| ESR/G Range | Test Frequency | | | | | | | |
|--------------|----------------|-------|---------|------|---------|------|---------|---------|
| | 100Hz | 200Hz | 500Hz | 1kHz | 2kHz | 5kHz | 10kHz | 20kHz |
| 1 μ S | | | B / B·C | | | | B / B·C | |
| 10 μ S | | | | | | | | |
| 100 μ S | A / A·B | | | | | | | |
| 1mS | | | | | | | | |
| 10mS | | | | | | | | |
| 100 Ω | A / A·B | | B / B·C | | A / A·B | | B / B·C | A / A·B |
| 10 Ω | | | | | | | | |
| 1 Ω | B / B·C | | | | | | | |

Alphabetic characters used in Table 2 represent:

Number of ESR/G Display Digits(*/**)

- * : MED measurement speed mode.
- ** : SLOW or FAST measurement speed mode (SLOW·FAST).

Figure 3-39. Number of Display Digits (Sheet 3 of 13).

Table 3. L-D Measurement

| L Range | Test Frequency | | | | | | | |
|---------|--|-------|-------|------|--|------|-------|-------|
| | 100Hz | 200Hz | 500Hz | 1kHz | 2kHz | 5kHz | 10kHz | 20kHz |
| 1kH | <div style="text-align: center;">See Graph 3 /See Graph 4 See Graph 3 /See Graph 4</div> | | | | | | | |
| 100H | | | | | | | | |
| 10H | | | | | | | | |
| 1H | | | | | | | | |
| 100mH | <div style="text-align: center;">B / B·C See Graph 9 /See Graph 10</div> | | | | <div style="text-align: center;">A / A·B See Graph 9 /See Graph 10</div> | | | |
| 10mH | | | | | | | | |
| 1mH | | | | | | | | |
| 100 μ H | | | | | | | | |

Alphabetic characters used in Table 3 represent:

Number of L Display Digits(*/**)
 Number of D Display Digits(*/**)

- * : MED measurement speed mode.
- ** : SLOW or FAST measurement speed mode (SLOW·FAST).

Figure 3-39. Number of Display Digits (Sheet 4 of 13).

Table 4. L-ESR/G Measurement

| ESR/G Range | Test Frequency | | | | | | | |
|-------------|----------------|-------|---------|---------|------|---------|-------|---------|
| | 100Hz | 200Hz | 500Hz | 1kHz | 2kHz | 5kHz | 10kHz | 20kHz |
| 10 μS | B / B·C | | | | | | | |
| 100 μS | A / A·B | | | | | | | |
| 1mS | | | | | | | | |
| 10mS | | | | | | | | |
| 100 Ω | A / A·B | | C / C·D | A / A·B | | C / C·D | | A / A·B |
| 10 Ω | B / B·C | | | B / B·C | | | | A / A·B |

Alphabetic characters used in Table 4 represent:

Number of ESR/G Display Digits(*/**)

- * : MED measurement speed mode.
- ** : SLOW or FAST measurement speed mode (SLOW·FAST).

Figure 3-39. Number of Display Digits (Sheet 5 of 13).

SECTION III

Table 5. Z - θ Measurement

| Z Range | Test Frequency | | | | | | | |
|---------------|--|-------|-------|------|------|------|-------|-------|
| | 100Hz | 200Hz | 500Hz | 1kHz | 2kHz | 5kHz | 10kHz | 20kHz |
| 10M Ω | See Graph 5 /See Graph 6 See Graph 5 /See Graph 6 | | | | | | | |
| 1M Ω | | | | | | | | |
| 100k Ω | | | | | | | | |
| 10k Ω | | | | | | | | |
| 1k Ω | | | | | | | | |
| 100 Ω | A / A·B See Graph 11 /See Graph 12 | | | | | | | |
| 10 Ω | | | | | | | | |
| 1 Ω | B / B·C See Graph 11 /See Graph 12 | | | | | | | |
| 100m Ω | | | | | | | | |

Alphabetic characters used in Table 5 represent:

Number of Z Display Digits(*/**)
Number of θ Display Digits(*/**)

- * : MED measurement speed mode.
- ** : SLOW or FAST measurement speed mode (SLOW·FAST).

Figure 3-39. Number of Display Digits (Sheet 6 of 13).

Table 6. Q Measurement.

| D Display | Q Display | D Display | Q Display |
|-----------------------|----------------------------------|---------------------|--------------------------------|
| .0001 to .0006 | OF | .001 to .006 | OF |
| .0007 to .0010 | 1000. | .007 to .010 | 100. |
| .0011 to .0033 | 300. to 300. | .011 to .033 | 90. to 30. |
| .0034 to .0099 | 290. to 100. | .034 to 1.999 | 30. to 1. |
| .0100 to .0333 | 100. to 30. | | |
| .0334 to 1.9999 | 29.9 to 5 | | |
| OF | 0 | | |

Figure 3-39. Number of Display Digits (Sheet 7 of 13).

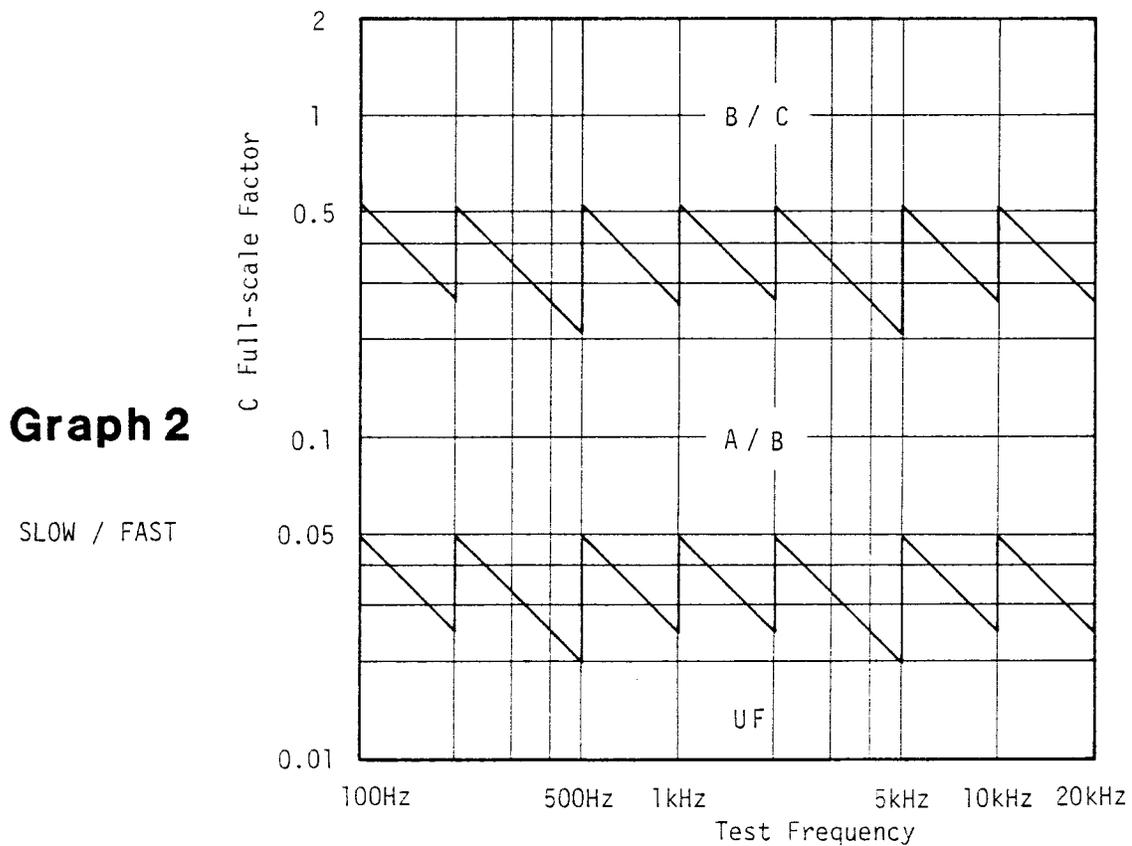
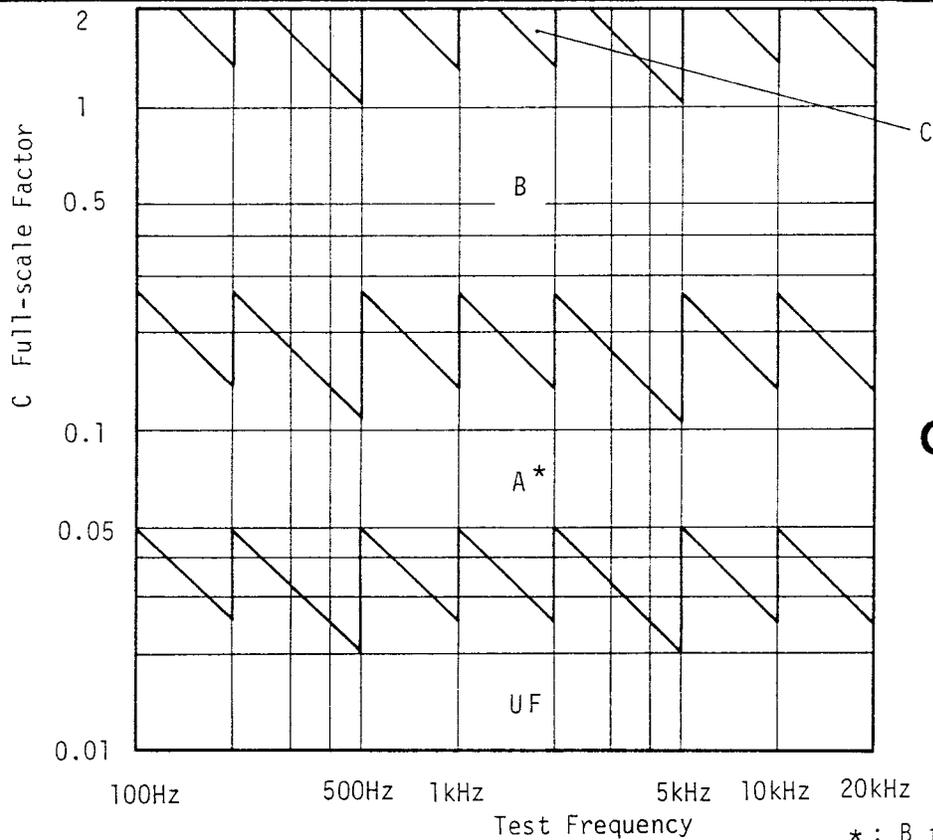


Figure 3-39. Number of Display Digits (Sheet 8 of 13).

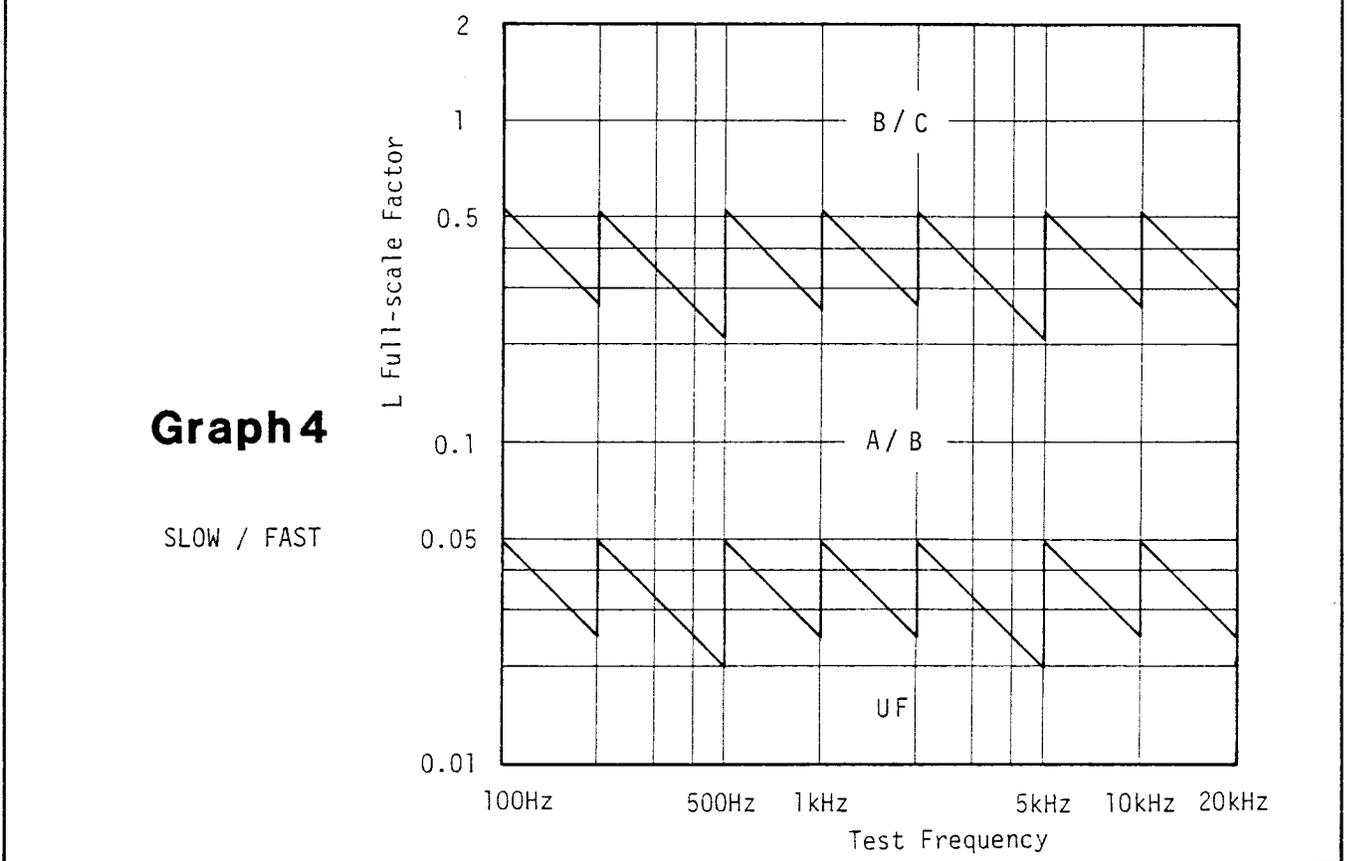
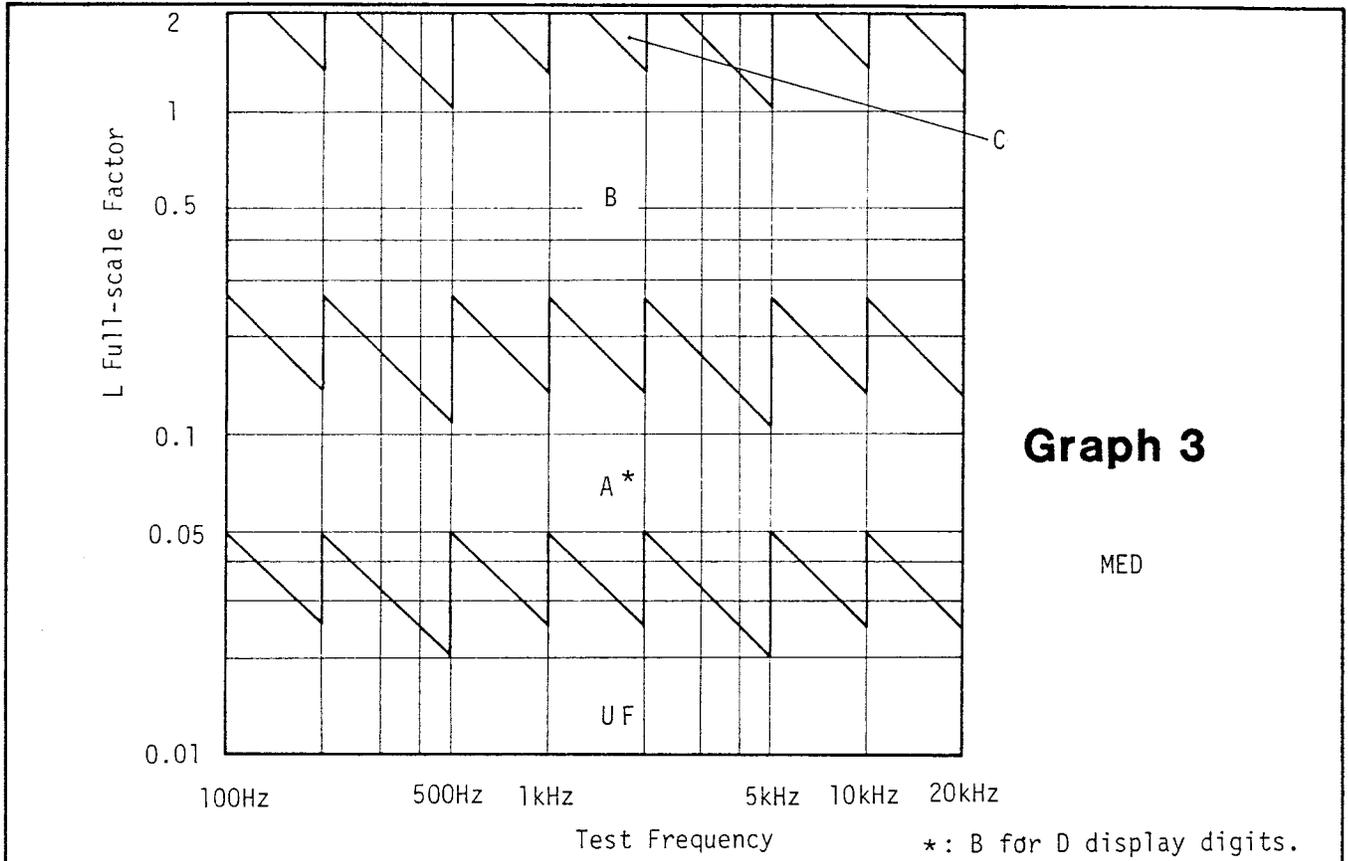


Figure 3-39. Number of Display Digits (Sheet 9 of 13).

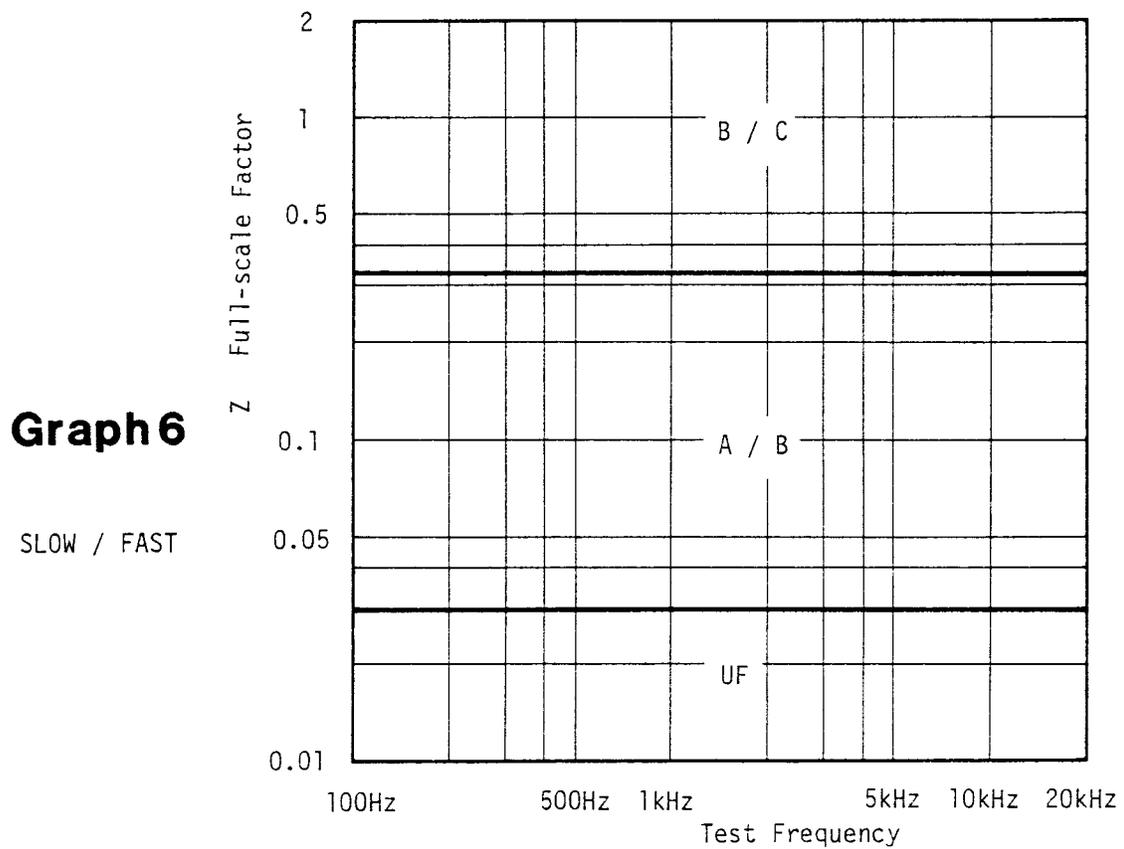
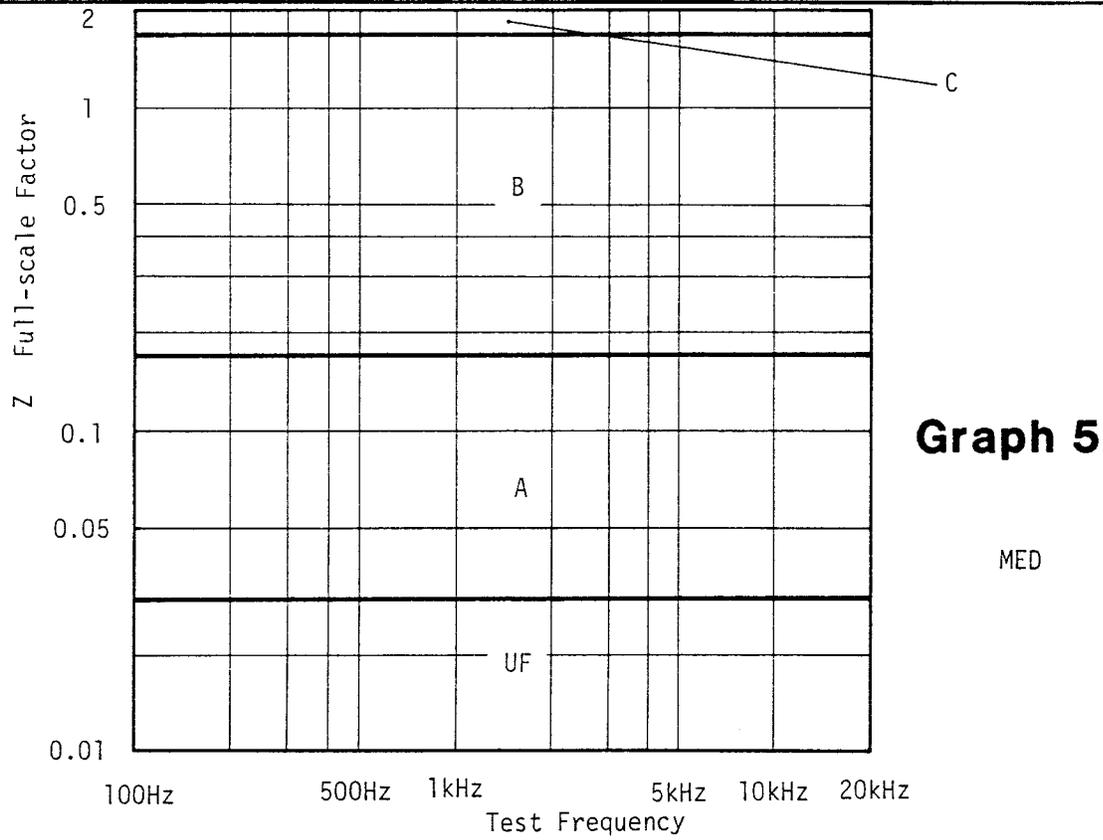


Figure 3-39. Number of Display Digits (Sheet 10 of 13).

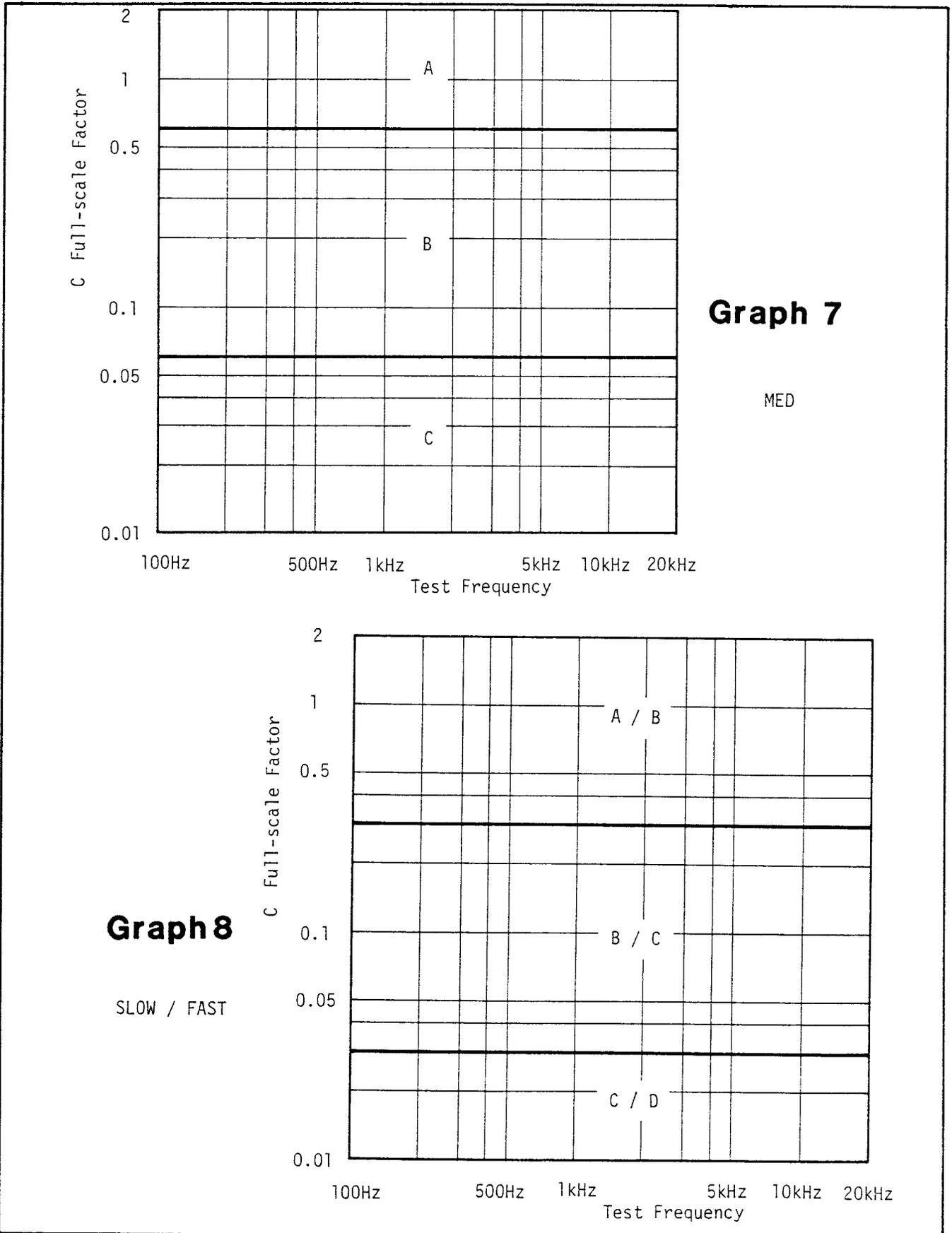


Figure 3-39. Number of Display Digits (Sheet 11 of 13).

SECTION III

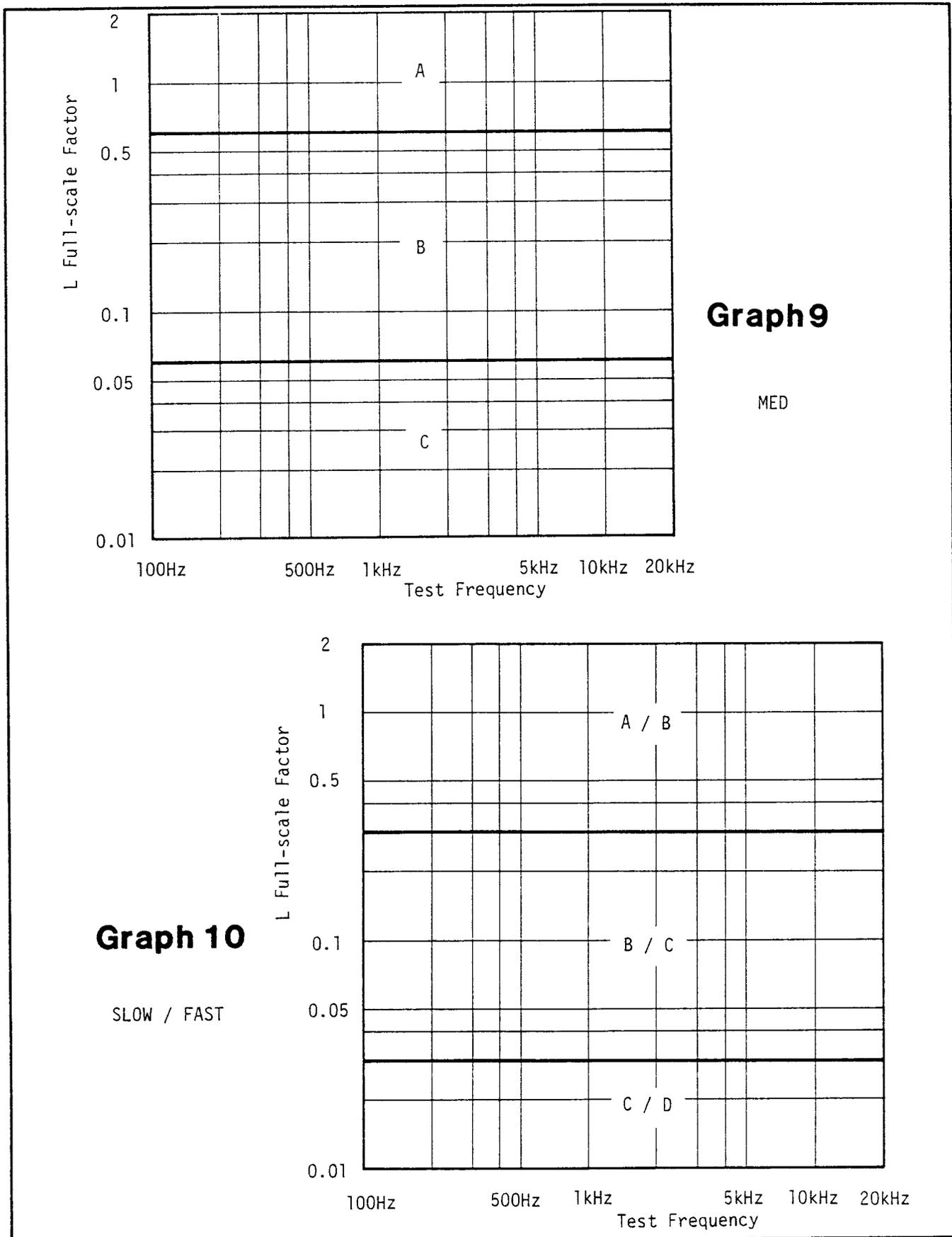


Figure 3-39. Number of Display Digits (Sheet 12 of 13).

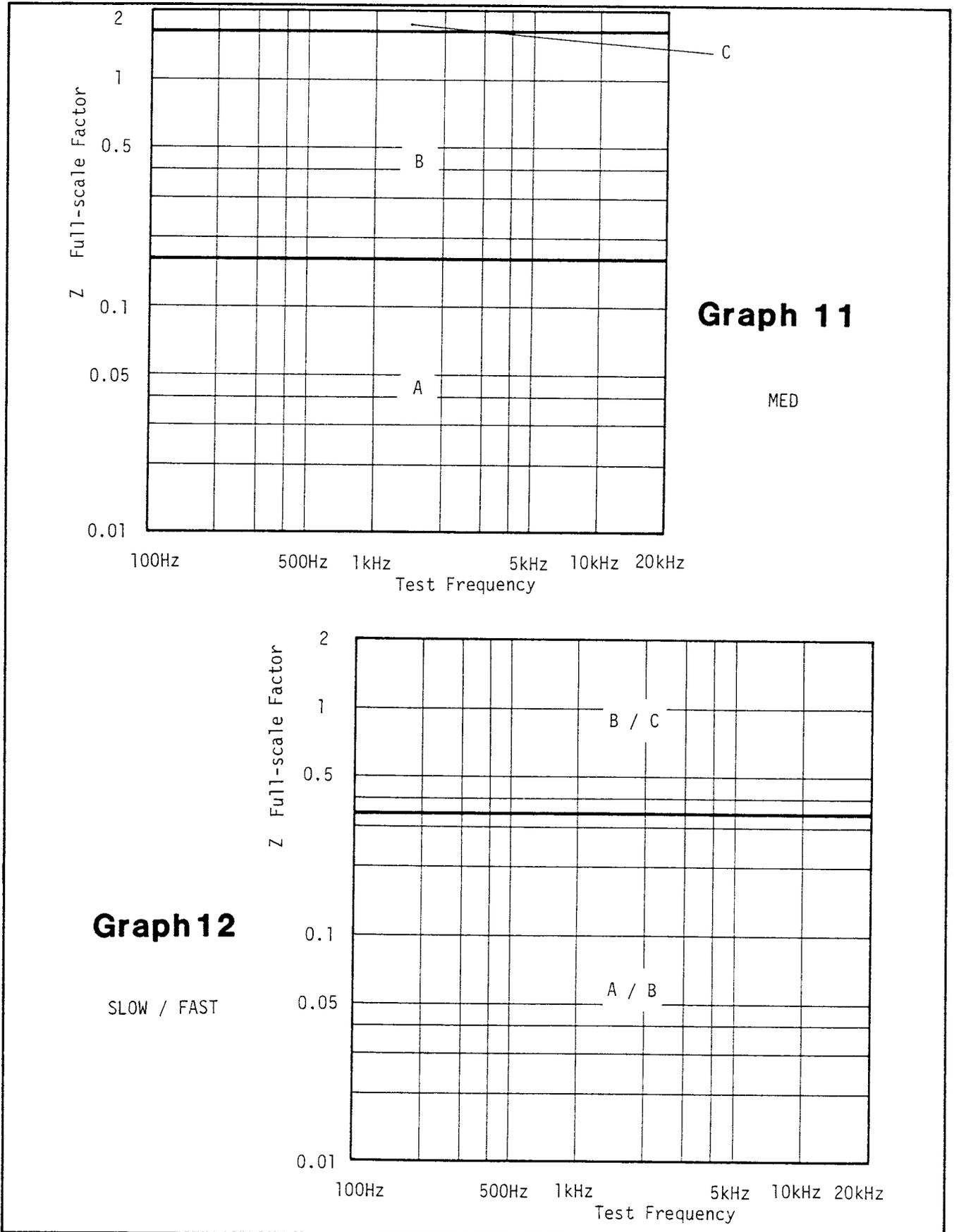


Figure 3-39. Number of Display Digits (Sheet 13 of 13).

SECTION IV

Table 4-1. Recommended Performance Test Equipment

| Equipment | Critical Specifications | Recommended Model | Use |
|-----------------------|--|---|---------------------------|
| Capacitance Standards | 10pF±0.4% 100pF±0.1% 1000pF±0.03% Usable frequencies: Up to 20kHz | HP 16382A HP 16383A HP 16384A | P, A |
| Resistance Standards | 0.1Ω 1Ω 10Ω 100Ω±0.03% 1kΩ±0.06% 10kΩ±0.06% 100kΩ±0.06% Usable frequencies: Up to 20kHz | HP 16074A Standard Resistor Set | P, A, T |
| Terminations | 0Ω SHORT OPEN Usable frequencies: Up to 20kHz | HP 16074A Standard Resistor Set | P, A |
| Frequency Counter | Frequency range: 100Hz to 100kHz f.s. Resolution: 1×10^{-5} of f.s. Accuracy: 0.001% | HP 5314A | P, A |
| Digital Multimeter | DCV: Voltage range: 10mV to 100V f.s. Resolution: 1×10^{-5} of f.s. Accuracy: 0.1% ACV: Voltage range: 100mV to 1Vrms f.s. Resolution: 1×10^{-2} of f.s. Accuracy: 3% in 100Hz to 20kHz | HP 3478A | P, A, T |
| RC Oscillator | Frequency: 1kHz Level: 1mV | HP 652A | T |
| Oscilloscope | Bandwidth: 100MHz Storage capability | HP 1741A | T |
| Signature Analyzer | | HP 5004A | T |
| Test Cables | BNC-to-BNC cable (<1m) 2EA BNC-to-dual banana plug cable (<1m) Dual banana plug-to-alligator clip cable BNC-to-dual alligator clip cable Alligator clip-to-alligator clip cable (<20cm) | HP 11170A HP 11035A HP 11002A (HP 11002A/w 10110B) | P, A, T P, A A A |
| BNC Adapter | BNC-T-Adapter | HP 1250-0781 | T |
| Test Fixture | Four terminal pair configuration design | HP 16047A | P |
| HP-IB Controller | | HP 85/ w0085-15003/ w82936A/ w82937A | P |
| Extender Board | Large extender board small extender board (for INTERNAL DC BIAS Adjustment) | HP 04276-66561 HP 04276-66562 | T A |

P: Performance Test, A: Adjustment, T: Troubleshooting

SECTION IV

PERFORMANCE TESTS

4-1. INTRODUCTION

4-2. This section provides the tests and the procedures used to verify the 4276A specifications listed in Table 1-1. All tests can be performed without access to the interior of the instrument. A simpler operational test is presented in Section III under Self Test. The performance tests can be used when performing incoming inspection of the instrument and when verifying that the instrument meets performance specifications after troubleshooting or adjustment or both. If the performance tests indicate that the instrument is operating outside specified limits, check to see if the controls on the instrument used in the test and the test setup itself are correct and then proceed with adjustments or troubleshooting or both.

Note

To ensure proper test results and instrument operation, Hewlett-Packard recommends a 30-minute warm-up and stabilization period before performing any of the performance tests.

Note

All performance tests except for the HP-IB Interface Test should be performed in an ambient temperature range of $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$.

4-3. EQUIPMENT REQUIRED

4-4. Equipment required to perform all of the performance tests is listed in Table 4-1. Any equipment that satisfies or exceeds the critical specifications listed in the table may be used as a substitute for the recommended models.

Accuracy checks described in this section use the HP 16380A series standard capacitors (16382A, 16383A and 16384A) and 16074A Standard Resistor Set. The characteristics of the equipment satisfy the performance requirements for the accuracy checks and are especially suited for use as the 4276A's accuracy test standards.

Note

Components used as standards should be calibrated by an instrument whose specifications are traceable to NBS or an equivalent standards group; or calibrated directly by an authorized calibration organization such as NBS. The calibration cycle should be in accordance with the stability specifications for each component.

4-5. TEST RECORD

4-6. Performance test results can be recorded on the Test Record at the completion of the test. The Test Record is at the end of this section and it lists all the tested specifications and their acceptable limits. Test results recorded at incoming inspection can be used for comparison in periodic maintenance, troubleshooting, and after repair or adjustment.

4-7. CALIBRATION CYCLE

4-8. This instrument requires periodic verification of performance. Depending on the conditions under which the instrument is used, e.g., environmental conditions or frequency of use, the instrument should be checked with the performance tests described here at least once a year. To keep instrument down-time to a minimum and to insure optimum operation, preventive maintenance should be performed at least twice a year.

ACCURACY TEST CONSIDERATIONS

This paragraph discusses how the 4276A accuracy is tested and verified. As the 4276A has wider measurement capabilities in regard to the selectable measurement parameters, frequency, measurement range and accuracy, the performance tests include some critical measuring regions where accuracy is difficult to verify directly by measuring available standards.

Measurement accuracy is tested by measuring standard capacitors, resistors and other reference devices. The standards must have been calibrated and certified by transfer of values of national standards. However, a portion of the measurement range of the 4276A is out of the applicable ranges of the available standards. The method then, is to check accuracies by comparison with references on the specific ranges at which the standards are applicable, and to apply alternative tests for verification of accuracies on the other ranges.

Theoretical Background of Accuracy Checks

The 4276A, in accordance with its measurement principles, determines the vector impedance (or its reciprocal value: admittance) of the unknown device under test. The various measurement data provided, with respect to the 8 selectable measurement parameters (L, C, D, etc.), are arithmetically derived from measured values of the orthogonal vector components (resistance and reactance). For example, the capacitance value of a DUT is calculated by the following equation relative to the capacitance-to-reactance values:

$$C_x = \frac{1}{2\pi f X_m}$$

where, C_x is capacitance value of DUT,
 f is test frequency,
 X_m is measured reactance value of DUT.

As stated above, each measurement parameter is interrelated with the impedance (or admittance) value; consequently, the accuracies on all ranges can be verified if the instrument satisfies specified accuracies for each one of its resistive and reactive measurement parameters; that is, resistance and capacitance from the lowest through the highest test frequencies.

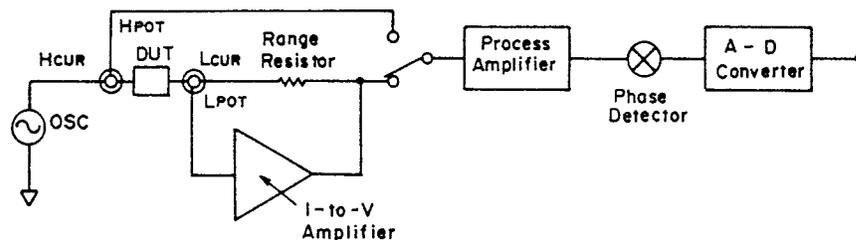
The technician should note that accuracy here is based on arithmetic relationships as are the parameter relationships. Therefore, the accuracy tests can be done by simplified procedures instead of time-consuming tests on the approximately 250000 possible combinations of the fundamental test parameters such as measurement parameter, frequency and range.

Verification Check Considerations

The measurement accuracy test can be made by using calibrated standards on specific ranges only. On other ranges, which would be uncertifiable because of the limitations of the standards, the test takes the method proven to be theoretically and experimentally practicable for verification of accuracy. If the results of these checks meet all the individual test limits, the instrument should satisfy its specified accuracy across its entire range. How then can these methods be explained? Let us look at the performance test articles.

Accuracy test procedures include checks for the following circuit sections:

- 1) Range Resistors
- 2) Process Amplifier
- 3) I-to-V Amplifier
- 4) Phase Detector
- 5) A-D (Analog to Digital) Converter



4276A Measurement Section

CAPACITANCE ACCURACY TEST verifies Range Resistor accuracy for reactive impedance measurements from the lowest through the highest test frequencies. I-to-V Amplifier linearity and normal operation of the Phase Detector and A-D Converter are also verified.

IMPEDANCE ACCURACY TEST is similar to the Capacitance Accuracy test, but for resistive impedance measurements. Thus, accuracy for both reactive and resistive components of the vector impedance is verified. In this test, phase-flatness characteristics (minimum phase shift) of the overall measurement section, and Phase Detector accuracy from the lowest through highest test frequencies are verified.

SELF-OPERATING TEST verifies the accuracy of the Process Amplifier which extends the measurement ranges. The A-D Converter accuracy is also checked by this combined self-test function which enables automatic check of each one of these circuits.

Note

A set of detection phases, each different by 90 degrees, is used in the Phase Detector. If the relative phase difference between the detection phases is exactly 90 degrees, the Phase Detector is operated at the maximum detection accuracy.

The accuracy of the right-angle detection phases is verified by both this test and dissipation factor checks associated with the Capacitance Accuracy Test.

ACCURACY TEST STANDARDS

1) Standard Capacitors

The HP 16380A Series Standard Capacitors, featuring the four terminal pair configuration, are recommended for use as performance test standards. The four standard capacitors, 16381A (1pF), 16382A (10pF), 16383A (100pF) and 16384A (1000pF) are calibrated at 0.01% accuracy at 1kHz (and have capacitances within 0.1% of their nominal values).

2) Standard Resistors

The standard resistors used for accuracy checks should be nearly pure resistances and should maintain an extremely low residual reactance at frequencies to 1MHz. The HP 16074A Standard Resistor Set, especially designed as standards useable over a broad frequency region, with thin film resistors and four terminal pair configurations, is suitable for the accuracy checks. Because of low residual inductance and less skin effect of the thin film resistors, the 16074A provides the standard resistance values of 0Ω, 0.1Ω, 1Ω and 10Ω at ±10% and 100Ω, 1kΩ, 10kΩ and 100kΩ at ±0.01% calibration accuracies to 10MHz (1MHz at 100kΩ). Open (OS) and Short terminations, which facilitate optimum zero offset adjustment, and two quasi-inductors are included in the 16074A.

Note

The 0Ω, 0.1Ω, 1Ω and 10Ω resistors are used as the (pure resistance) reference device in the Impedance Accuracy Test. Two quasi-inductors are not used in the 4276A performance tests.

3) The principle of Inductance Accuracy Test

The 4276A inductance accuracy is theoretically certified if the capacitance accuracy meets the specifications. Generally, inductors have unwanted parasitic impedances such as coil resistance and distributed capacitance. As these residuals significantly affect the inductance values at high frequencies, inductance standards useable in the RF region above 100kHz are substantially unavailable. Inductors with higher inductance values have lower frequency limits.

If it is desired to check inductance measurement accuracy, use standard capacitors as a substitution test device. The capacitors act as negative inductors when measured in inductance measurement function of the 4276A. The equivalent inductance value of capacitor is calculated by the following equation:

$$Z = \frac{1}{j\omega C} = j\omega L$$

$$L = \frac{1}{-\omega^2 C}$$

C: Calibrated value of standard capacitor
 ω : 2π · [test frequency]

GENERAL

The standards should be of four terminal pair configuration design to provide compatibility with the instrument. This minimizes reduction in reliability of the values due to the effects of the residuals associated with cabling and connections.

PERFORMANCE TESTS

4-9. **TEST FREQUENCY ACCURACY TEST**

4-10. This test verifies that the test signal frequencies for the 4276A meet the specified frequency accuracy of 0.01%.

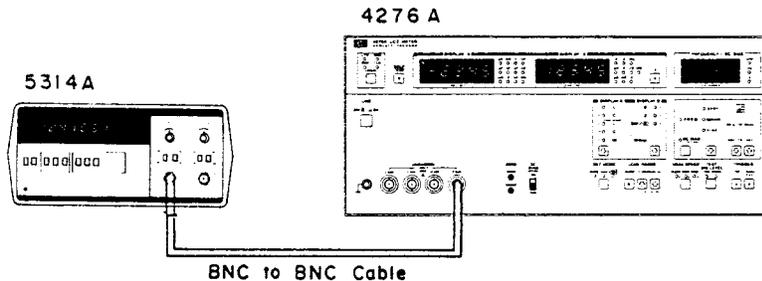


Figure 4-1. Test Frequency Accuracy Test Setup.

EQUIPMENT:

- Frequency Counter HP 5314A
- BNC-to-BNC cable HP 11170A

PROCEDURE:

1. Connect the BNC-to-BNC cable to the 4276A UNKNOWN H_{CUR} terminal and to the 5314A's input as shown in Figure 4-1.
2. Set the 4276A's controls as follows:
 - Test Frequency 1.00kHz
 - DC BIAS OFF
 - TEST SIG LEVEL HIGH
 - TRIGGER MAN/EXT
 - Other controls Any setting
3. Verify that the frequency reading on the 5314A is 1.000kHz±0.1Hz.
4. Set test frequency in accordance with Table 4-2 and confirm that the frequency readings on the 5314A are within the test limits given in the table.

Note

- 1) Test limit values in the table do not account for the tolerance dependent on the specified accuracy of the 5314A.
- 2) If this test fails, the instrument requires troubleshooting.

PERFORMANCE TESTS

Table 4-2. Test Frequency Accuracy Test

| Frequency Setting | Test Limits |
|-------------------|--------------------|
| 100Hz | 99.99 - 100.01Hz |
| 200Hz | 199.98 - 200.02Hz |
| 500Hz | 499.95 - 500.05Hz |
| 1.00kHz | 999.9 - 1000.1Hz |
| 2.00kHz | 1.9998 - 2.0002kHz |
| 5.00kHz | 4.9995 - 5.0005kHz |
| 10.0kHz | 9.999 - 10.001kHz |
| 20.0kHz | 19.998 - 20.002kHz |

4-11. TEST SIGNAL LEVEL ACCURACY TEST

4-12. This test verifies that the test signal level for the 4276A meets the specified test signal level accuracy.

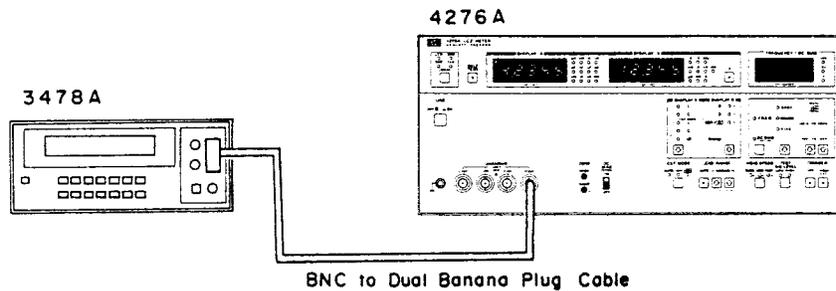


Figure 4-2. Test Signal Level Accuracy Test Setup.

EQUIPMENT:

- Digital Multimeter HP 3478A
- BNC-to-dual banana plug cable HP 11035A

Note

Use a digital multimeter calibrated for a frequency response of 100Hz to 20kHz.

PROCEDURE:

1. Connect the BNC-to-dual banana plug cable to the UNKNOWN H_CUR terminal of the 4276A and to the 3478A's input as shown in Figure 4-2.
2. Set the 4276A's controls as follows:

- DISPLAY A/B functions C-D
- Test Frequency 1.00kHz
- DC BIAS OFF
- LC|Z| RANGE 1nF
- TEST SIG LEVEL HIGH
- TRIGGER MAN/EXT
- Other controls Any setting

PERFORMANCE TESTS

3. Set the function of the 3478A to ACV.
4. Verify that the voltage reading on the 3478A is 1.0Vrms±0.1Vrms.
5. Change test frequency and test signal level settings in accordance with Table 4-3. Verify that the voltage readings on the 3478A are within the test limits given in the table.

Table 4-3. Test Signal Level Accuracy Test

| Control Settings | | Test Limits |
|------------------|----------------|--------------|
| Test Level | Test Frequency | |
| HIGH | 100Hz | .7 - 1.3Vrms |
| | 200Hz | .7 - 1.3Vrms |
| | 500Hz | .7 - 1.3Vrms |
| | 1.00kHz | .9 - 1.1Vrms |
| | 2.00kHz | .7 - 1.3Vrms |
| | 5.00kHz | .7 - 1.3Vrms |
| | 10.0kHz | .7 - 1.3Vrms |
| | 20.0kHz | .7 - 1.3Vrms |
| LOW | 100Hz | 35 - 65mVrms |
| | 1.00kHz | 40 - 60mVrms |
| | 10.0kHz | 35 - 65mVrms |

4-13. SELF-OPERATING TEST

4-14. The Self-operating Test checks operating conditions of the circuits which are critical to sustaining specified accuracies. To verify that these circuits satisfy the performance requirements for ensuring the specified accuracies, the values displayed in the SELF TEST are compared with test limits. Because basic circuit operating conditions related to the accuracy are verified in this test, the instrument should be initially checked with this test.

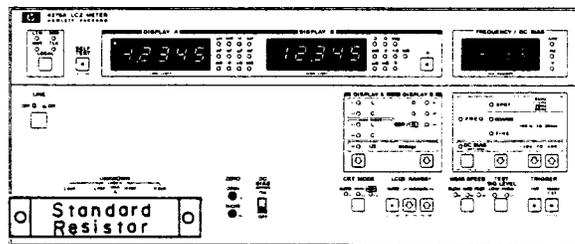


Figure 4-3. Self Operating Test Setup.

EQUIPMENT:

- | | | |
|--------------------------|-------|--------------------------------------|
| Standard Resistors | 1Ω | } HP 16074A Standard Resistor Set |
| | 100Ω | |
| | 1kΩ | |
| | 10kΩ | |
| | 100kΩ | |
| Termination | OPEN | |

PERFORMANCE TESTS

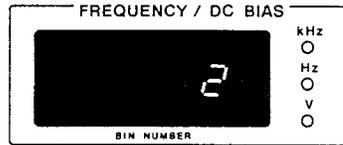
PROCEDURE:

1. Connect the 100kΩ Standard Resistor directly to UNKNOWN terminals of the 4276A as shown in Figure 4-3.
2. Set the 4276A's controls as follows:

```

DISPLAY A/B functions ..... | Z | - θ
Test Frequency ..... 1.00kHz
DC BIAS ..... OFF
CKT MODE ..... Any setting
LC | Z | RANGE ..... 1MΩ
MEAS SPEED ..... MED
TEST SIG LEVEL ..... HIGH
TRIGGER..... INT
    
```

3. Press the SELF TEST key and then press the FREQUENCY/DC BIAS Select key. Press the FREQUENCY/DC BIAS Step Control  key until Self test item number "2" is displayed on the FREQUENCY/DC BIAS display as shown below.



4. Verify that the value displayed on DISPLAY A is 10.00 μS ± 0.01 μS.
5. Change Standard Resistor to 10kΩ, 1kΩ and 100Ω in that order and change LC | Z | RANGE  key each time. Verify that the display outputs are within the test limits given in the table below.

| Standard Resistor | Range | Limits |
|-------------------|-------|------------------|
| 100kΩ | 10μS | 1/C.V. ± 0.01μS |
| 10kΩ | 100μS | 1/C.V. ± 0.1μS |
| 1kΩ | 1mS | 1/C.V. ± 0.001mS |
| 100Ω | 10mS | 1/C.V. ± 0.01mS |

1/C.V. = Reciprocal of Calibrated Value

6. Press SELF TEST to resume measurement mode and set the 4276A's controls as follows:

```

DISPLAY A/B functions ..... C-G
Test Frequency ..... 1.00kHz
DC BIAS ..... OFF
CKT MODE ..... Any setting
LC | Z | RANGE ..... 1mF
MEAS SPEED ..... MED
TEST SIG LEVEL ..... HIGH
TRIGGER ..... INT
    
```

7. Connect the 1Ω Standard Resistor directly to the UNKNOWN terminals as shown in Figure 4-3.
8. Repeat step 3.

PERFORMANCE TESTS

9. Verify that the values displayed on DISPLAY A and DISPLAY B are within the following test limits.

DISPLAY A: C.V. \pm .02 Ω
 DISPLAY B: 0 \pm .012 Ω

10. Set the MEAS SPEED to SLOW and connect the OPEN termination to the UNKNOWN terminals in place of the 1 Ω standard.
11. Select SELF TEST "8" by pressing the FREQUENCY/DC BIAS Step Control key until "8" appears on the FREQUENCY/DC BIAS display.
12. Confirm that the values displayed on DISPLAY A and DISPLAY B are within the following test limits:

DISPLAY A: .0020 \pm .0003
 DISPLAY B: -.0020 \pm .0003

13. Perform the test for the self test steps and the test frequencies shown in the table below in the same way. Confirm that the values displayed on DISPLAY A and DISPLAY B are within the test limits given in the table.

Note

To change the test frequency setting while the 4276A is in SELF TEST mode, press the FREQUENCY/DC BIAS Select key (FREQ lamp should light), set the frequency with the FREQUENCY/DC BIAS Control keys (⊖ and ⊕), and then press the FREQUENCY/DC BIAS Select key again (DC BIAS lamp should light).

| SELF TEST NUMBER | 1.00kHz | | 20.0kHz | |
|------------------|-------------------|--------------------|---------------|---------------|
| | DISP A | DISP B | DISP A | DISP B |
| 8 | .0020 \pm .0003 | -.0020 \pm .0003 | | |
| 9 | 0 \pm .0020 | 0 \pm .0013 | 0 \pm .0080 | 0 \pm .0052 |
| 12 | 0 \pm .0012 | 0 \pm .0020 | 0 \pm .0048 | 0 \pm .0043 |
| 13 | 0 \pm .0012 | 0 \pm .0020 | 0 \pm .0048 | 0 \pm .0043 |
| 14 | 0 \pm .0024 | 0 \pm .0020 | 0 \pm .0096 | 0 \pm .0036 |
| 15 | 0 \pm .0048 | 0 \pm .0020 | 0 \pm .0192 | 0 \pm .0360 |

PERFORMANCE TESTS

Table 4-4. Capacitance Accuracy Tests

| Standard Capacitance | Function | Speed | Level | Frequency | Test Limits | | | | |
|----------------------|--------------------|---------------------|---------------|------------------|-------------------|---------------|---------|-------------------|---------------|
| 10pF | C-D | MED | HIGH | 9.95kHz | C.V. \pm .16pF | 0 \pm .010 | | | |
| | | | | 10.0kHz | C.V. \pm .16pF | 0 \pm .010 | | | |
| | | | | 20.0kHz | C.V. \pm .24pF | 0 \pm .012 | | | |
| 100pF | C-D | MED | HIGH | 995Hz | C.V. \pm .6pF | 0 \pm .004 | | | |
| | | | | 1.00kHz | C.V. \pm .35pF | 0 \pm .0035 | | | |
| | | | | 1.99kHz | C.V. \pm .65pF | 0 \pm .0065 | | | |
| | | | | 4.98kHz | C.V. \pm .25pF | 0 \pm .0017 | | | |
| | | | | 9.95kHz | C.V. \pm .70pF | 0 \pm .0046 | | | |
| | | | | 10.0kHz | C.V. \pm .70pF | 0 \pm .0046 | | | |
| | | | | 20.0kHz | C.V. \pm 2.20pF | 0 \pm .0140 | | | |
| 1000pF | C-D | MED | HIGH | 100Hz | C.V. \pm 5.0pF | 0 \pm .0050 | | | |
| | | | | 120Hz | C.V. \pm 5.0pF | 0 \pm .0050 | | | |
| | | | | 199Hz | C.V. \pm 6.5pF | 0 \pm .0065 | | | |
| | | | | 498Hz | C.V. \pm 2.5pF | 0 \pm .0017 | | | |
| | | | | 995Hz | C.V. \pm 2.5pF | 0 \pm .0017 | | | |
| | | | | 1.00kHz | C.V. \pm 1.5pF | 0 \pm .0011 | | | |
| | | | | 1.99kHz | C.V. \pm 2.5pF | 0 \pm .0017 | | | |
| | | | | 4.98kHz | C.V. \pm 2.5pF | 0 \pm .0017 | | | |
| | | | | 9.95kHz | C.V. \pm 7.0pF | 0 \pm .0046 | | | |
| | | | | 10.0kHz | C.V. \pm 7.0pF | 0 \pm .0046 | | | |
| | | | | 20.0kHz | C.V. \pm 11.0pF | 0 \pm .0070 | | | |
| | | | | SLOW | HIGH | HIGH | 100Hz | C.V. \pm 5.0pF | 0 \pm .0050 |
| | | | | | | | 1.00kHz | C.V. \pm 1.50pF | 0 \pm .0011 |
| | 10.0kHz | C.V. \pm 7.0pF | 0 \pm .0046 | | | | | | |
| | FAST | HIGH | HIGH | 100Hz | C.V. \pm 10pF | 0 \pm .010 | | | |
| | | | | 1.00kHz | C.V. \pm 6pF | 0 \pm .006 | | | |
| | | | | 10.0kHz | C.V. \pm 16pF | 0 \pm .014 | | | |
| | MED FAST MED | LOW | LOW | 1.00kHz | C.V. \pm 12pF | 0 \pm .011 | | | |
| | | | | 1.00kHz | C.V. \pm 100pF | 0 \pm .100 | | | |
| | | | | 10.0kHz | C.V. \pm 32pF | 0 \pm .027 | | | |
| HIGH SPEED | MED | HIGH LOW HIGH | 1.00kHz | C.V. \pm 1.5pF | | | | | |
| | | | 1.00kHz | C.V. \pm 12pF | | | | | |
| | | | 10.0kHz | C.V. \pm 7.0pF | | | | | |

C.V. = Calibrated Value of Standard Capacitor

PERFORMANCE TESTS

4-17. **IMPEDANCE ACCURACY TEST**

4-18. This test checks impedance measurement accuracies at four spot test frequencies. The checks are made by connecting a standard resistor to the instrument and comparing the measurement readouts with the calibrated values of the standard.

| Range Freq. | 0.1Ω | 1Ω | 10Ω | 100Ω | 1kΩ | 10kΩ | 100kΩ |
|----------------|------|----|-----|------|-----|------|-------|
| 100Hz | △ | △ | △ | ○ | ○ | ○ | ○ |
| 120Hz | △ | △ | △ | ○ | ○ | ○ | ○ |
| 1.00kHz | △ | △ | △ | ○ | ○ | ○ | ○ |
| 10.0kHz | △ | △ | △ | ○ | ○ | ○ | ○ |

○ : tested for both |Z| and θ.
 △ : tested for θ only.

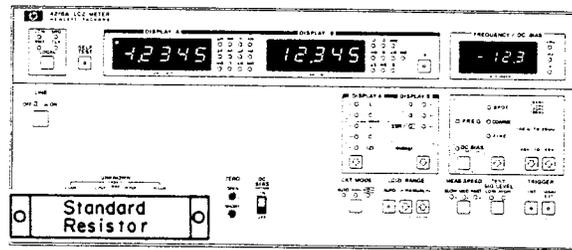


Figure 4-5. Impedance Accuracy Test Setup.

EQUIPMENT:

- Standard Resistors 0.1Ω
 - 1Ω
 - 10Ω
 - 100Ω
 - 1kΩ
 - 10kΩ
 - 100kΩ
 - Terminations 0Ω
 - OPEN
- HP 16074A Standard Resistor Set

PROCEDURE:

1. Set the 4276A's controls as follows:

- DISPLAY A/B functions |Z| - θ
- Test Frequency Any setting
- DC BIAS OFF
- CKT MODE AUTO
- LC |Z| RANGE AUTO
- MEAS SPEED MED
- TEST SIG LEVEL HIGH
- TRIGGER INT

PERFORMANCE TESTS

2. Perform OPEN and SHORT Zero Offset Adjustment as described in paragraph 3-48.

Note

Use the OPEN and 0Ω terminations of the 16074A for Zero Offset Adjustment. DO NOT use the SHORT termination.

3. Connect the 0.1Ω standard resistor directly to UNKNOWN terminals as shown in Figure 4-5 and set test frequency to 100Hz, 120Hz, 1kHz and 10kHz. Verify that the impedance and phase angle readings on the 4276A are within the test limits given in Table 4-5.
4. Repeat step 3 with the each of the standard resistors listed in Table 4-5. Verify that the values displayed on the 4276A meet the test limits given in the table.

Table 4-5. Impedance Accuracy Tests

| Z Range | | Test Limits | | | | | | |
|----------|---|-------------|--------|--------|-----------|----------|------------|-----------|
| | | 0.1Ω | 1Ω | 10Ω | 100Ω | 1kΩ | 10kΩ | 100kΩ |
| 100Hz | Z | / | / | / | C.V.±.15Ω | C.V.±6Ω | C.V.±.06kΩ | C.V.±.6kΩ |
| | θ | 0±1.2° | 0±.7° | 0±.35° | 0±.15° | 0±.6° | 0±.6° | 0±.6° |
| 120Hz | Z | / | / | / | C.V.±.15Ω | C.V.±6Ω | C.V.±.06kΩ | C.V.±.6kΩ |
| | θ | 0±1.2° | 0±.7° | 0±.35° | 0±.15° | 0±.6° | 0±.6° | 0±.6° |
| 1.00kHz | Z | / | / | / | C.V.±.15Ω | C.V.±6Ω | C.V.±.06kΩ | C.V.±.6kΩ |
| | θ | 0±1.2° | 0±.7° | 0±.35° | 0±.15° | 0±.6° | 0±.6° | 0±0.6° |
| 10.0kHz | Z | / | / | / | C.V.±.25Ω | C.V.±10Ω | C.V.±.1kΩ | C.V.±1kΩ |
| | θ | 0±2.2° | 0±1.2° | 0±.65° | 0±.25° | 0±1.0° | 0±1.0° | 0±1.0° |

C.V. = Calibrated Value of Standard Resistors

4-19. **INDUCTANCE ACCURACY TEST**

4-20. Inductance accuracy is verified if the instrument meets both capacitance and impedance accuracy test limits. If it is desired to confirm the inductance accuracy on at least at one range, perform the following test:

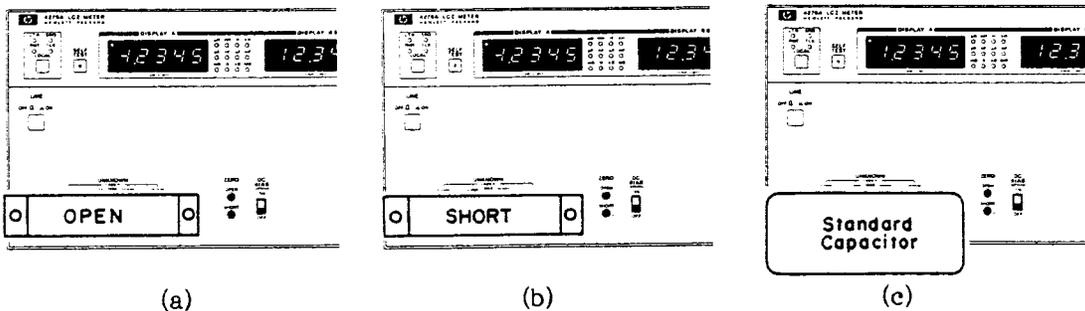


Figure 4-6. Inductance Accuracy Test Setup.

PERFORMANCE TESTS

EQUIPMENT:

Digital MultimeterHP 3478A
 Test FixtureHP 16047A

PROCEDURE:

1. Set the 4276A's controls as follows:

DISPLAY A/B functionsC-D
 Test Frequency.....20.0kHz
 LC | Z | RANGE.....100nF
 TFST SIG LEVELLOW
 TRIGGER.....MAN/EXT
 DC BIAS (Front Panel)ON
 DC BIAS (Rear Panel)INT
 Other controlsAny setting

2. Interconnect the 4276A, 16047A, and 3478A as shown in Figure 4-7.
3. Set dc bias voltage to +40V with the FREQUENCY/DC BIAS Select key and the FREQUENCY/DC BIAS Step Control  key. Wait approximately 10 seconds after setting the voltage.
4. Set DC bias voltage in accordance with Table 4-6. After the wait time specified in the table, read the voltage displayed on the 3478A. Verify that the voltage readings are within the test limits given in the table.

Table 4-6. Internal DC Bias Accuracy Test

| DC BIAS Setting | Wait Time | Test Limits |
|-----------------|------------|-------------|
| +40.0V | 10 seconds | Precharge |
| .00 | 30 | 0±.01V |
| +.01 | 20 | .01±.01V |
| +9.99 | 10 | 9.99±.04V |
| +10.0 | 10 | 10.0±.085V |
| +40.0 | 15 | 40.0±.24V |
| -.01 | 30 | -.01±.01V |
| -9.99 | 10 | -9.99±.11V |
| -10.0 | 10 | -10.0±.135V |
| -40.0 | 15 | -40.0±.44V |

PERFORMANCE TESTS

4-23. **16064A COMPARATOR/HANDLER INTERFACE TEST (OPTION 002)**

4-24. The test in this paragraph, verifies the functions of the 16064A Comparator/Handler Interface.

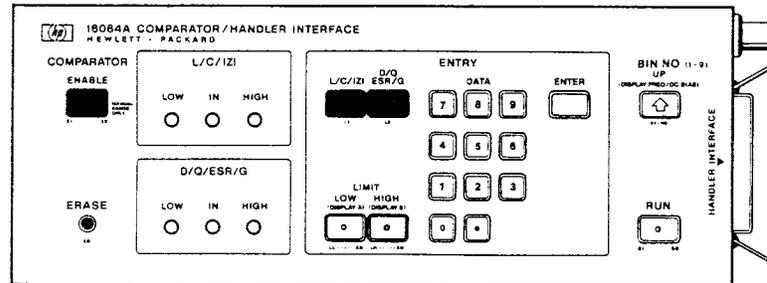


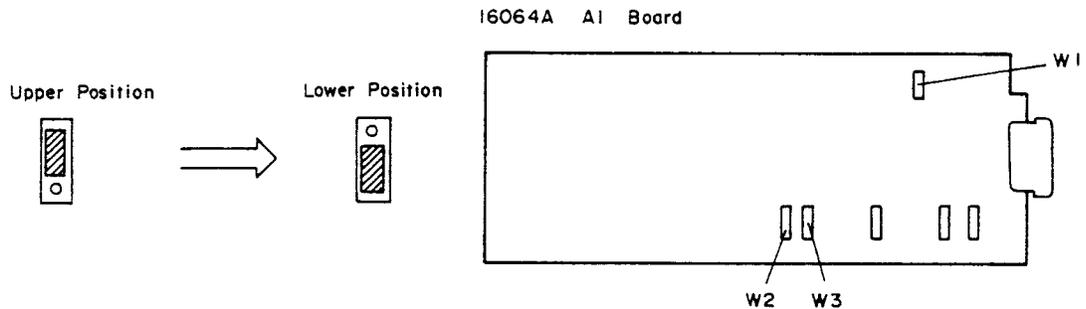
Figure 4-8. 16064A Comparator/Handler Interface.

EQUIPMENT:

| | |
|---------------------------------|-----------|
| Digital Multimeter | HP 3478A |
| 100kΩ Standard resistor | HP 16074A |
| 1000pF Standard capacitor | HP 16384A |

PROCEDURE:

1. Set jumpers A1 W1/W2/W3 in the 16064A to the lower position as shown below:



2. Connect the 16064A to the COMPARATOR/HANDLER INTERFACE connector on the rear panel of the 4276A.
3. Turn on the 4276A. "16064" should be displayed on DISPLAY B.
4. Set the 4276A's controls as follows:

| | |
|-----------------------------|---------|
| DISPLAY A/B functions | C-G |
| Test Frequency | 1.00kHz |
| DC BIAS | OFF |
| CKT MODE | |
| LC Z RANGE | 1nF |
| MEAS SPEED | MED |
| TEST SIG LEVEL | HIGH |
| TRIGGER | INT |

PERFORMANCE TESTS

- Set the 3478A's controls as follows:

Function DCV
 RANGE 300V
 Display 3 1/2 digits

- Connect the 3478A's LO input to the 4276A's GUARD terminal.

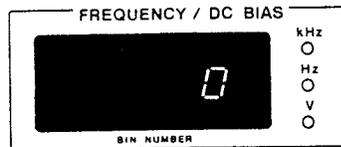
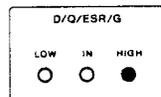
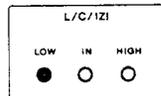
- Press the ERASE key on the 16064A and set the following comparator limits:

L/C/|Z| LOW LIMIT (BIN1): .3
 L/C/|Z| HIGH LIMIT (BIN1): .9
 D/Q/ESR/G LOW LIMIT: 2
 D/Q/ESR/G HIGH LIMIT: 8

- Connect the 100kΩ standard resistor directly to the 4276A's UNKNOWN terminals.

- Press the RUN key on the 16064A's control panel.

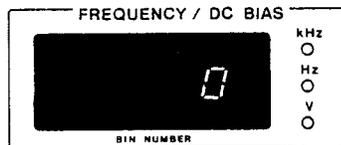
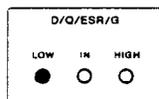
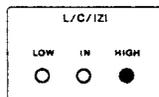
- Verify that the L/C/|Z| LOW and D/Q/ESR/G HIGH lamps light, and that "0" is displayed on the 4276A's FREQUENCY/DC BIAS DISPLAY.



- Check the states of the comparison data output (TTL) at the HANDLER INTERFACE connector using the 3478A. The pin assignments and the data states are shown in Figure 4-9 and Table 4-7.

- Disconnect the 100kΩ resistor and connect the 1000pF standard capacitor.

- Verify that the L/C/|Z| HIGH and D/Q/ESR/G LOW lamps light, and that "0" is displayed on the 4276A's FREQUENCY/DC BIAS DISPLAY.



- Check the comparison data output at the HANDLER INTERFACE connector by comparing it with the Data States shown in Table 4-7.

PERFORMANCE TESTS

4-25. HP-IB INTERFACE TEST

4-26. This test verifies the instrument's HP-IB capabilities.

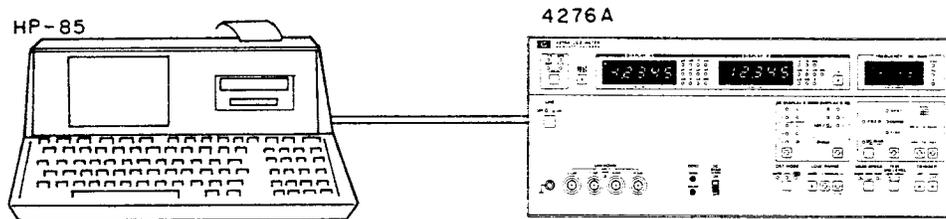


Figure 4-10. HP-IB Interface Test Setup.

EQUIPMENT:

| | |
|-------------------------|----------------|
| Personal Computer | HP-85 |
| I/O ROM | HP 00085-15003 |
| ROM Drawer | HP 82936A |
| HP-IB Interface | HP 82937A |
| 100pF Standard | HP 16383A |

PROCEDURE:

1. Turn off the 4276A and the HP-85.
2. Connect the 82937A HP-IB Interface between the HP-85 and the 4276A as shown in Figure 4-8, and install the I/O ROM into the HP-85.
3. Set the 4276A's HP-IB Control switch, located on the rear panel, as follows:

| | |
|----------|-----------------------|
| bits 5-1 | : 10001 (17_{10}) |
| bit 6 | : 0 |
| bit 7 | : 0 |
4. Turn on the 4276A and the HP-85.
5. Load one of the three test programs into the personal computer. Test programs are listed on pages 4-21, 4-23 and 4-25.
6. Execute the program and follow the prompts and instructions output by the HP-85. Details on the controller's (personal computer) instructions and the appropriate operator response are given in Tables 4-8 through 4-10.

PERFORMANCE TESTS

TEST PROGRAM 1

PURPOSE:

This test verifies that the 4276A has the following HP-IB capabilities:

- (1) Remote/Local Capability
- (2) Local Lockout
- (3) Talk Disable
- (4) Listen Disable

PROGRAM LISTING:

```

10 ! 4276A HP-IB TEST No.1
20 ! REMOTE/LOCAL TEST
30 DIM A$(1)
40 N=0 @ M=7 @ M1=717
50 S=SPOLL(M1)
60 CLEAR
70 PRINT "*** 4276A HP-IB TEST No.1 ***"
80 DISP "REMOTE/LOCAL TEST"
90 REMOTE M
100 OUTPUT M1 ;"T1"
110 DISP "LISTEN=1,TALK=0,REMOTE=1"
120 GOSUB 580
130 ABORTIO M
140 DISP "LISTEN=0,TALK=0,REMOTE=1"
150 GOSUB 580
160 LOCAL M
170 DISP "LISTEN=0,TALK=0,REMOTE=0"
180 GOSUB 580
190 REMOTE M1
200 DISP "LISTEN=1,TALK=0,REMOTE=1"
210 GOSUB 580
220 LOCAL LOCKOUT M
230 DISP "PRESS LOCAL KEY"
240 DISP "LISTEN=1,TALK=0,REMOTE=1"
250 GOSUB 580
260 LOCAL M1
270 DISP "LISTEN=1,TALK=0,REMOTE=0"
280 GOSUB 580
290 REMOTE M1
300 OUTPUT M1 ;"T1"
310 DISP "LISTEN=1,TALK=0,REMOTE=1"
320 GOSUB 580
330 IF N=1 THEN 340 ELSE 370
340 PRINT "REMOTE/LOCAL TEST FAIL"
350 DISP "REMOTE/LOCAL TEST FAIL"
360 GOTO 390
370 PRINT "REMOTE/LOCAL TEST PASS"
380 DISP "REMOTE/LOCAL TEST PASS"
390 N=0
400 DISP "LISTEN/TALK TEST"
410 ENTER M1 ; A
420 DISP "LISTEN=0,TALK=1,REMOTE=1"
430 GOSUB 580
440 OUTPUT M1 ;"T1"
450 DISP "LISTEN=1,TALK=0,REMOTE=1"
460 GOSUB 580
470 IF N=1 THEN 480 ELSE 510
480 PRINT "LISTEN/TALK TEST FAIL"
490 DISP "LISTEN/TALK TEST FAIL"
500 GOTO 530
510 PRINT "LISTEN/TALK TEST PASS"
520 DISP "LISTEN/TALK TEST PASS"
530 PRINT "END"
540 DISP "END"
550 CLEAR M
560 LOCAL M
570 END
580 INPUT A$
590 IF A$="N" THEN N=1
600 RETURN

```

PERFORMANCE TESTS

Table 4-8. Controller Instructions and Operator Responses for Test Program 1

| Controller Instructions | | Operator Response |
|---|-------------------------------|---|
| Displays | Printout | |
| | *** 4276A HP-IB TEST NO.1 *** | |
| REMOTE/LOCAL TEST | | |
| LISTEN=1*, TALK=0, REMOTE=1 LISTEN=0, TALK=0, REMOTE=1 LISTEN=0, TALK=0, REMOTE=0 LISTEN=1, TALK=0, REMOTE=1 | | If the 4276A HP-IB Status Indicators and Controller Display are the same, press Y , and END LINE . If not, press N , and END LINE . |
| PRESS LOCAL KEY | | Press Local Key. |
| LISTEN=1, TALK=0, REMOTE=1 LISTEN=1, TALK=0, REMOTE= LISTEN=1, TALK=0, REMOTE=1 | | If the 4276A HP-IB Status Indicators and Controller Display are the same, press Y , and END LINE . If not, press N , and END LINE . |
| REMOTE/LOCAL TEST PASS | REMOTE/LOCAL TEST PASS | If all steps are correct, this message is output. |
| REMOTE/LOCAL TEST FAIL | REMOTE/LOCAL TEST FAIL | If any step fails, this message is output. |
| LISTEN/TALK TEST | | |
| LISTEN=0, TALK=1, REMOTE=1 LISTEN=1, TALK=0, REMOTE=1 | | If the 4276A HP-IB Status Indicators and Controller Display are the same, press Y , and END LINE . If not, press N , and END LINE . |
| LISTEN/TALK TEST PASS | LISTEN/TALK TEST PASS | If both steps are correct, this message is output. |
| LISTEN/TALK TEST FAIL | LISTEN/TALK TEST FAIL | If any step fails, this message is output. |
| END | END | |

*1 indicates ON; 0 indicates OFF.

PERFORMANCE TESTS

TEST PROGRAM 2**PURPOSE:**

This test verifies that the 4276A has the following HP-IB capabilities:

- (1) Talker
- (2) Device Trigger

PROGRAM LISTING:

```
10 ! 4276A HP-IB TEST No.2
20 ! TALKER TEST
30 DIM A$(100),B$(1)
40 M=7 @ M1=717
50 S=SPOLL(M1)
60 PRINT "*** 4276A HP-IB TEST No.2 ***"
70 CLEAR
80 DISP "TALKER TEST"
90 DISP "CONNECT 100pF"
100 BEEP
110 PAUSE
120 DISP "DATA OUTPUT TEST"
130 REMOTE M
140 ABORTIO M
150 CLEAR M1
160 OUTPUT M1 ;"A2B1F1T2"
170 DISP "TEST FREQUENCY IN kHz ";
180 INPUT F
190 OUTPUT M1 ;"FR",F,"EN"
200 TRIGGER M1
210 ENTER M1 ; A,B
220 DISP A*1.E12;"pF",B
230 DISP "IS OUTPUT DATA CORRECT (Y or N) ";
240 INPUT B$
250 IF B$="N" THEN 260 ELSE 290
260 PRINT "DATA OUTPUT TEST FAIL"
270 DISP "DATA OUTPUT TEST FAIL"
280 GOTO 310
290 PRINT "DATA OUTPUT TEST PASS"
300 DISP "DATA OUTPUT TEST PASS"
310 DISP "COMPLETE DATA OUTPUT TEST"
320 TRIGGER M1
330 ENTER M1 ; A$
340 DISP A$
350 DISP "IS OUTPUT DATA CORRECT (Y or N) ";
360 INPUT B$
370 IF B$="N" THEN 380 ELSE 410
380 PRINT "COMPLETE DATA OUTPUT TEST FAIL"
390 DISP "COMPLETE DATA OUTPUT TEST FAIL"
400 GOTO 430
410 PRINT "COMPLPETE DATA OUTPUT TEST PASS"
420 DISP "COMPLETE DATA OUTPUT TEST PASS"
430 PRINT "END"
440 DISP "END"
450 CLEAR M
460 LOCAL M
470 END
```

PERFORMANCE TESTS

Table 4-9. Controller Instructions and Operator Responses for Test Program 2

| Controller Instructions | | Operator Responses |
|--|--|---|
| Displays | Printout | |
| | *** 4276A HP-IB TEST No.2 *** | |
| TALKER TEST | | |
| CONNECT 100pF | | Connect the 16383A (100pF Standard) to the UNKNOWN terminals. |
| DATA OUTPUT TEST TEST FREQUENCY IN kHz ? | | Key in the desired test frequency value, from 0.1 to 20, and press END LINE . |
| [Capacitance] [Dissipation Factor] IS OUTPUT DATA CORRECT (Y or N) ? | | If the output data is the same as the values displayed on each 4276A display, press Y and END LINE . If not, press N and END LINE . |
| | DATA OUTPUT TEST PASS DATA OUTPUT TEST FAIL | DATA OUTPUT TEST result. |
| COMPLETE DATA OUTPUT TEST | | |
| PNC[Capacitance],ND[Dissipation Factor] IS OUTPUT DATA CORRECT (Y or N) ? | | If the output data is the same as the left values, press Y and END LINE . If not, press N and END LINE . |
| | COMPLETE DATA OUTPUT TEST PASS COMPLETE DATA OUTPUT TEST FAIL | COMPLETE DATA OUTPUT TEST result. |
| | END | |

PERFORMANCE TESTS

TEST PROGRAM 3**PURPOSE:**

This test program verifies that the 4276A has the following HP-IB capabilities:

- (1) Service Request
- (2) Serial Poll

PROGRAM LISTING:

```

10 ! 4276A HP-IB TEST No.3
20 ! SRQ TEST
30 S=0 @ M=7 @ M1=717
40 DN INTR 7 GOSUB 560
50 CLEAR
60 PRINT "*** 4276A HP-IB TEST No.3 ***"
70 PRINT "SRQ TEST"
80 DISP "SRQ TEST"
90 REMOTE M
100 ABORTIO M
110 CLEAR M1
120 DISP "DATA READY SRQ TEST"
130 OUTPUT M1 ;"D1T2"
140 TRIGGER M1
150 GOSUB 480
160 PRINT "DATA READY SRQ TEST PASS"
170 S=0
180 DISP "SYNTAX ERROR SRQ TEST"
190 OUTPUT M1 ;"D0A6DA"
200 GOSUB 480
210 PRINT "SYNTAX ERROR SRQ TEST PASS"
220 S=0
230 DISP "SELF TEST END SRQ TEST"
240 OUTPUT M1 ;"S1"
250 DISP "SELF TEST in progress"
260 GOSUB 480
270 IF BIT(S,2)=0 THEN GOSUB 480
280 OUTPUT M1 ;"S0"
290 PRINT "SELF TEST END SRQ TEST PASS"
300 S=0
310 DISP "TRIGGER TOO FAST SRQ TEST"
320 DISP "MOMENTARILY GROUND"
330 DISP "EXT TRG CONNECTOR"
340 GOSUB 510
350 GOSUB 480
360 PRINT "TRG TOO FAST SRQ TEST PASS"
370 S=0
380 DISP "OPERATIONAL ERROR SRQ TEST"
390 OUTPUT M1 ;"N1N2"
400 GOSUB 480
410 PRINT "OPERATIONAL ERROR SRQ TEST PASS"
420 PRINT "SRQ TEST END"
430 CLEAR M1
440 ABORTIO M
450 LOCAL M
460 DISP "END"
470 END
480 ENABLE INTR 7;8
490 IF S>0 THEN DISP S @ RETURN
500 GOTO 480
510 OUTPUT M1 ;"F1T2DA"
520 TRIGGER M1
530 ENTER M1 ; A,B
540 IF S=0 THEN 510
550 RETURN
560 S=SPOLL(M1) @ STATUS 7,1 ; 2
570 IF BIT(S,5)=1 THEN 590
580 DISP "OTHER DEVICE SRQ"
590 ENABLE INTR 7;8
600 RETURN

```

PERFORMANCE TESTS

Table 4-10. Controller Instructions and Operator Responses for Test Program 3

| Controller Instructions | | Operator Response |
|---|---------------------------------|--|
| Displays | Printout | |
| | *** 4276A HP-IB TEST No.3 *** | |
| SRQ TEST | SRQ TEST | |
| DATA READY SRQ TEST 65 | DATA READY SRQ TEST PASS | SRQ Status Byte data should be 65 [=01000001]. |
| SYNTAX ERROR SRQ TEST 66 | SYNTAX ERROR SRQ TEST PASS | SRQ Status Byte data should be 66 [=01000010]. |
| SELF TEST END SRQ TEST SELF TEST in progress 68 | SELF TEST END SRQ TEST PASS | SRQ Status Byte data should be 68 [=01000100]. If the instrument fails SELF TEST, it should be 84 [=01010100]. |
| TRIGGER TOO FAST SRQ TEST MOMENTARILY GROUND EXT TRG CONNECTOR 72* ¹ | TRG TOO FAST SRQ TEST PASS | Ground EXT TRG Connector on rear panel momentarily. SRQ Status Byte data should be 72 [=01001000]. |
| OPERATIONAL ERROR SRQ TEST 80* ² | OPERATIONAL ERROR SRQ TEST PASS | SRQ Status Byte data should be 80 [=01010000]. |
| | SRQ TEST END | |

*₁: SRQ Status Byte data may be 73 [=01001001] due to the timing of connecting the EXT TRG pin to ground.

*₂: SRQ Status Byte data may be 81 [=01010001] due to the timing of connecting the EXT TRG pin to ground.

SECTION IV

PERFORMANCE TEST RECORD

| Paragraph Number | TEST | Results | | | | |
|------------------|------------------------------|---|--------------------|------------------------|-------------------|----------------------|
| | | Minimum | Actual | Maximum | | |
| 4-13 | SELF-OPERATING TEST (Cont'd) | | | | | |
| | 1.00kHz | | | | | |
| | SELF TEST #8 | DISPLAY A DISPLAY B | 0.0017 -0.0023 | _____ | 0.0023 -0.0017 | |
| | SELF TEST #9 | DISPLAY A DISPLAY B | -0.0020 -0.0013 | _____ | 0.0020 0.0013 | |
| | SELF TEST #12 | DISPLAY A DISPLAY B | -0.0012 -0.0020 | _____ | 0.0012 0.0020 | |
| | SELF TEST #13 | DISPLAY A DISPLAY B | -0.0012 -0.0020 | _____ | 0.0012 0.0020 | |
| | SELF TEST #14 | DISPLAY A DISPLAY B | -0.0024 -0.0020 | _____ | 0.0024 0.0020 | |
| | SELF TEST #15 | DISPLAY A DISPLAY B | -0.0048 -0.0020 | _____ | 0.0048 0.0020 | |
| | 20.0kHz | | | | | |
| | SELF TEST #9 | DISPLAY A DISPLAY B | -0.0080 -0.0052 | _____ | 0.0080 0.0052 | |
| | SELF TEST #12 | DISPLAY A DISPLAY B | -0.0048 -0.0043 | _____ | 0.0048 0.0043 | |
| | SELF TEST #13 | DISPLAY A DISPLAY B | -0.0048 -0.0043 | _____ | 0.0048 0.0043 | |
| | SELF TEST #14 | DISPLAY A DISPLAY B | -0.0096 -0.0036 | _____ | 0.0096 0.0036 | |
| | SELF TEST #15 | DISPLAY A DISPLAY B | -0.0192 -0.0360 | _____ | 0.0192 0.0360 | |
| | 4-15 | CAPACITANCE ACCURACY TEST | | | | |
| | | 10pF Range Speed: MED Level: HIGH | | | | |
| | | 9.95kHz | C D | C.V. - .16pF - .010 | _____ | C.V. + .16pF .010 |
| | | 10.0kHz | C D | C.V. - .16pF - .010 | _____ | C.V. + .16pF .010 |
| | | 20.0kHz | C D | C.V. - .24pF - .012 | _____ | C.V. + .24pF .012 |

C.V. = Calibrated Value

PERFORMANCE TEST RECORD

| Paragraph Number | TEST | Results | | | |
|------------------|------------------------------------|--------------|---------------|--------------|---------------|
| | | Minimum | Actual | Maximum | |
| 4-15 | CAPACITANCE ACCURACY TEST (Cont'd) | | | | |
| | 100pF Range | | | | |
| | Speed: MED | | | | |
| | Level: HIGH | | | | |
| | 995Hz | C | C.V. - .6pF | _____ | C.V. + .6pF |
| | | D | - .004 | _____ | .004 |
| | 1.00kHz | C | C.V. - .35pF | _____ | C.V. + .35pF |
| | | D | - .0035 | _____ | .0035 |
| | 1.99kHz | C | C.V. - .65pF | _____ | C.V. + .65pF |
| | | D | - .0065 | _____ | .0065 |
| | 4.98kHz | C | C.V. - .25pF | _____ | C.V. + .25pF |
| | | D | - .0017 | _____ | .0017 |
| | 9.95kHz | C | C.V. - .70pF | _____ | C.V. + .70pF |
| | | D | - .0046 | _____ | .0046 |
| | 10.0kHz | C | C.V. - .70pF | _____ | C.V. + .70pF |
| | | D | - .0046 | _____ | .0046 |
| | 20.0kHz | C | C.V. - 2.20pF | _____ | C.V. + 2.20pF |
| | | D | - .0140 | _____ | .0140 |
| | 1000pF Range | | | | |
| | Speed: MED | | | | |
| | Level: HIGH | | | | |
| | 100Hz | C | C.V. - 5.0pF | _____ | C.V. + 5.0pF |
| | | D | - .0050 | _____ | .0050 |
| | 120Hz | C | C.V. - 5.0pF | _____ | C.V. + 5.0pF |
| | D | - .0050 | _____ | .0050 | |
| 199Hz | C | C.V. - 6.5pF | _____ | C.V. + 6.5pF | |
| | D | - .0065 | _____ | .0065 | |
| 498Hz | C | C.V. - 2.5pF | _____ | C.V. + 2.5pF | |
| | D | - .0017 | _____ | .0017 | |
| 995Hz | C | C.V. - 2.5pF | _____ | C.V. + 2.5pF | |
| | D | - .0017 | _____ | .0017 | |
| 1.00kHz | C | C.V. - 1.5pF | _____ | C.V. + 1.5pF | |
| | D | - .0011 | _____ | .0011 | |
| 1.99kHz | C | C.V. - 2.5pF | _____ | C.V. + 2.5pF | |
| | D | - .0017 | _____ | .0017 | |
| 4.98kHz | C | C.V. - 2.5pF | _____ | C.V. + 2.5pF | |
| | D | - .0017 | _____ | .0017 | |
| 9.95kHz | C | C.V. - 7.0pF | _____ | C.V. + 7.0pF | |
| | D | - .0046 | _____ | .0046 | |

C.V. = Calibrated Value

SECTION IV

PERFORMANCE TEST RECORD

| Paragraph Number | TEST | Results | | | |
|--|--|---------|---------------|-------------|---------------|
| | | Minimum | Actual | Maximum | |
| 4-15 | CAPACITANCE ACCURACY TEST (Cont'd) | | | | |
| | 10.0kHz | C | C.V. - 7.0pF | _____ | C.V. + 7.0pF |
| | | D | - .0046 | _____ | .0046 |
| | 20.0kHz | C | C.V. - 11.0pF | _____ | C.V. + 11.0pF |
| | | D | - .0070 | _____ | .0070 |
| | 1000pF Range Speed: SLOW Level: HIGH | | | | |
| | 100Hz | C | C.V. - 5.0pF | _____ | C.V. + 5.0pF |
| | | D | - .0050 | _____ | .0050 |
| | 1.00kHz | C | C.V. - 1.5pF | _____ | C.V. + 1.5pF |
| | | D | - .0011 | _____ | .0011 |
| | 10.0kHz | C | C.V. - 7.0pF | _____ | C.V. + 7.0pF |
| | | D | - .0046 | _____ | .0046 |
| | 1000pF Range Speed: FAST Level: HIGH | | | | |
| | 100Hz | C | C.V. - 10pF | _____ | C.V. + 10pF |
| | | D | - .010 | _____ | .010 |
| | 1.00kHz | C | C.V. - 6pF | _____ | C.V. + 6pF |
| | | D | - .006 | _____ | .006 |
| | 10.0kHz | C | C.V. - 16pF | _____ | C.V. + 16pF |
| | | D | - .014 | _____ | .014 |
| | 1000pF Range Level: LOW | | | | |
| | Speed: MED | 1.00kHz | C | C.V. - 12pF | _____ |
| | | D | - .011 | _____ | .011 |
| Speed: FAST | 1.00kHz | C | C.V. - 100pF | _____ | C.V. + 100pF |
| | | D | - .100 | _____ | .100 |
| Speed: MED | 10.0kHz | C | C.V. - 32pF | _____ | C.V. + 32pF |
| | | D | - .027 | _____ | .027 |
| 1000pF Range HIGH SPEED C Speed: MED | | | | | |
| Level: HIGH | 1.00kHz | | C.V. - 1.5pF | _____ | C.V. + 1.5pF |
| Level: LOW | 1.00kHz | | C.V. - 12pF | _____ | C.V. + 12pF |
| Level: HIGH | 10.0kHz | | C.V. - 7.0pF | _____ | C.V. + 7.0pF |

C.V. = Calibrated Value

PERFORMANCE TEST RECORD

| Paragraph Number | TEST | | | Results | | |
|------------------|-------------------------|---------|---------|-----------------------|----------------|---------------------|
| | | | | Minimum | Actual | Maximum |
| 4-17 | IMPEDANCE ACCURACY TEST | | | | | |
| | 100mΩ Range | 100Hz | θ | - 1.2° | _____ | 1.2° |
| | | 120Hz | θ | - 1.2° | _____ | 1.2° |
| | | 1.00kHz | θ | - 1.2° | _____ | 1.2° |
| | | 10.0kHz | θ | - 2.2° | _____ | 2.2° |
| | 1Ω Range | 100Hz | θ | - .7° | _____ | .7° |
| | | 120Hz | θ | - .7° | _____ | .7° |
| | | 1.00kHz | θ | - .7° | _____ | .7° |
| | | 10.0kHz | θ | - 1.2° | _____ | 1.2° |
| | 10Ω Range | 100Hz | θ | - .35° | _____ | .35° |
| | | 120Hz | θ | - .35° | _____ | .35° |
| | | 1.00kHz | θ | - .35° | _____ | .35° |
| | | 10.0kHz | θ | - .65° | _____ | .65° |
| | 100Ω Range | 100Hz | Z θ | C.V. - .15Ω - .15° | _____ _____ | C.V. + .15Ω .15° |
| | | 120Hz | Z θ | C.V. - .15Ω - .15° | _____ _____ | C.V. + .15Ω .15° |
| | | 1.00kHz | Z θ | C.V. - .15Ω - .15° | _____ _____ | C.V. + .15Ω .15° |
| | | 10.0kHz | Z θ | C.V. - .25Ω - .25° | _____ _____ | C.V. + .25Ω .25° |
| | 1kΩ Range | 100Hz | Z θ | C.V. - 6Ω - .6° | _____ _____ | C.V. + 6Ω .6° |
| | | 120Hz | Z θ | C.V. - 6Ω - .6° | _____ _____ | C.V. + 6Ω .6° |
| | | 1.00kHz | Z θ | C.V. - 6Ω - .6° | _____ _____ | C.V. + 6Ω .6° |
| | | 10.0kHz | Z θ | C.V. - 10Ω - 1.0° | _____ _____ | C.V. + 10Ω 1.0° |
| | 10kΩ Range | 100Hz | Z θ | C.V. - .06kΩ - .6° | _____ _____ | C.V. + .06kΩ .6° |
| | | 120Hz | Z θ | C.V. - .06kΩ - .6° | _____ _____ | C.V. + .06kΩ .6° |

C.V. = Calibrated Value

PERFORMANCE TEST RECORD

| Paragraph Number | TEST | Results | | |
|------------------|--|---|--------|---|
| | | Minimum | Actual | Maximum |
| 4-17 | IMPEDANCE ACCURACY TEST (Cont'd) | | | |
| | 1.00kHz Z θ | C.V. - .06kΩ - .6° | _____ | C.V. + .06kΩ .6° |
| | 10.0kHz Z θ | C.V. - .1kΩ - 1.0° | _____ | C.V. + .1kΩ 1.0° |
| | 100kΩ Range 100Hz Z θ | C.V. - .6kΩ - .6° | _____ | C.V. + .6kΩ .6° |
| | 120Hz Z θ | C.V. - .6kΩ - .6° | _____ | C.V. + .6kΩ .6° |
| | 1.00kHz Z θ | C.V. - .6kΩ - .6° | _____ | C.V. + .6kΩ .6° |
| | 10.0kHz Z θ | C.V. - 1kΩ - 1.0° | _____ | C.V. + 1kΩ 1.0° |
| 4-19 | INDUCTANCE ACCURACY TEST Frequency: 1.00kHz Speed: MED Level: HIGH DISPLAY A DISPLAY B | - 25.51 - .012 | _____ | - 25.15 .012 |
| 4-21 | INTERNAL DC BIAS ACCURACY TEST (OPTION 001 ONLY) Precharge + 40V Wait: 10sec. .00V Wait: 30sec. + .01V Wait: 20sec. + 9.99V Wait: 10sec. + 10.0V Wait: 10sec. + 40.0V Wait: 15sec. - .01V Wait: 30sec. - 9.99V Wait: 10sec. - 10.0V Wait: 10sec. - 40.0V Wait: 15sec. | - .01V 0V 9.95V 9.015V 39.76V - .02V - 10.1V - 10.135V - 40.44V | _____ | .01V .02V 10.03V 10.85V 40.24V 0V - 9.88V - 9.865V - 39.56V |

C.V. = Calibrated Value

Table 5-1. Adjustable Components (Sheet 1 of 2)

| Reference Designator | Name of Control | Purpose |
|--|--|---|
| A1 R3 (Para. 5-18) | | Sets the reset voltage level. |
| A2 R1 (Para. 5-19) | OSC/LEVEL | Sets the test signal level. |
| A2 R4 A2 R5 A2 R6 A2 R7 (Para. 5-24) | 10K/MAG 1K/MAG 100/MAG 100K/MAG | Fine adjustment for range resistor. |
| A2 R13 (Para. 5-20) | ER/OFS | Eliminates dc offset voltage from ERR buffer amplifier. |
| A2 R14 (Para. 5-23) | LF TRK | Compensates for phase offset between the EDUT and ERR buffer amplifiers. |
| A2 R15 (Para. 5-20) | ED/OFS | Eliminates dc offset voltage from the EDUT buffer amplifier. |
| A2 R16 (Para. 5-20) | LC/OFS | Eliminates dc offset voltage from the I/V amplifier. |
| A2 R17 (Para. 5-20) | DIF/OFS | Eliminates dc offset voltage from the differential amplifier and the process amplifier. |
| A2 R25 (Para. 5-20) | AM1/OFS | Eliminates dc offset voltage from the AM1 amplifier. |
| A2 R26 A2 R27 A2 R35 (Para. 5-22) | AF 1/2 AF 1/5 AM 1/10 | Sets AM/AF attenuation. |
| A2 R39 (Para. 5-20) | AF/OFS | Eliminates dc offset voltage from the AF amplifier. |
| A2 R40 (Para. 5-20) | AM2/OFS | Eliminates dc offset voltage from the AM2 amplifier. |
| A2 R99 A2 R100 (Para. 5-21) | ZERO ZERO SHIFT | Sets the zero detect voltage level. |
| A2 C2 C3 (Para. 5-25) | 10K/PH 100K/PH | Eliminates range resistor phase offset. |
| A2 C7 (Para. 5-23) | HF TRK | Compensates for phase offset between the EDUT and ERR buffer amplifiers. |
| A2 C12 A2 C13 A2 C18 (Para. 5-22) | PH 1/2 PH 1/5 PH 1/10 | Eliminates AM/AF attenuator phase offset. |

SECTION V

Table 5-1. Adjustable Components (Sheet 2 of 2)

| Reference Designator | Name of Control | Purpose |
|--|-----------------|--|
| A4 R14 (Para. 5-17) (Para. 5-18) | V-ADJ | Sets power supply voltage. |
| A4 R15 (Para. 5-17) | F-ADJ | Sets power supply switching frequency. |
| A22 R6 A22 R7 A22 R8 (Para. 5-26) | ZERO FS | Eliminates bias voltage offset and gain error. |

SECTION V ADJUSTMENTS

5-1. INTRODUCTION

5-2. This section describes the adjustments and checks required to return the 4276A to the specifications listed in Table 1-1 after repairs have been made. These adjustments and checks can also be performed along with periodic maintenance to keep the instrument in optimum operating condition. The recommended adjustment cycle for the 4276A is twice a year. All adjustable components referred to in the adjustment procedures are listed in Table 5-1. If proper performance cannot be achieved after adjustment, refer to the troubleshooting procedures described in Section VIII.

Note

All options that the instrument is normally equipped with must be installed before the adjustments described in this section are made. If the options are installed after the instrument is adjusted, the specifications listed in Table 1-1 are not guaranteed.

Note

To ensure proper results and correct instrument operation, Hewlett-Packard suggests a 30-minute warm-up and stabilization period before performing any of the adjustments described here.

5-3. SAFETY REQUIREMENTS

5-4. Although the 4276A was designed in accordance with international safety standards, this manual contains information, cautions, and warnings which must be followed to ensure operator safety and to keep the instrument in a safe and serviceable condition. Adjustments described in this section should be performed by qualified service personnel only.

WARNING

ANY INTERRUPTION OF THE PROTECTIVE (GROUNDED) CONDUCTOR (INSIDE OR OUTSIDE THE INSTRUMENT) OR DISCONNECTION OF THE PROTECTIVE EARTH TERMINAL IS LIKELY TO MAKE THE

INSTRUMENT DANGEROUS. INTENTIONAL INTERRUPTION, FOR ANY REASON, IS PROHIBITED.

5-5. The removal or opening of covers for removal or adjustment of parts, other than those which are accessible by hand, will expose live parts.

5-6. Capacitors in the instrument may still be charged even if the instrument has been disconnected from the power source (AC line) for an extended period of time.

WARNING

ADJUSTMENTS DESCRIBED IN THIS SECTION ARE PERFORMED WITH POWER SUPPLIED AND PROTECTIVE COVERS REMOVED. ENERGY EXISTING AT MANY POINTS MAY, IF CONTACTED, RESULT IN SERIOUS PERSONAL INJURY.

5-7. EQUIPMENT REQUIRED

5-8. All the equipment required to perform the adjustments described in this section are listed in Table 4-1 on page 4-0. Each piece of equipment listed in Table 4-1 should be calibrated to satisfy its own specifications, as well as those of the required characteristics. If the recommended model is not available, any instrument whose specifications equal or surpass those of the recommended model may be used instead.

5-9. FACTORY SELECTED COMPONENTS

5-10. Factory selected components are identifiable by an asterisk (*) adjacent to the reference designator on the schematic diagrams in Section VIII (only nominal values are given). Table 5-2 lists the reference designators of all factory selected components. Also listed in Table 5-2 are the nominal value range of each component and a brief description of how each component affects instrument performance.

Adjustable components, with reference designators, are listed in Table 5-1. This table also lists the name of the adjustment and its purpose.

SECTION V

5-11. ADJUSTMENT RELATIONSHIPS

5-12. The adjustment procedures described in this section, beginning with paragraph 5-17, are interactive and therefore should be performed in the sequence given. Ignoring or changing the order of the procedures may make it impossible to obtain optimum instrument performance. Table 5-3 lists the necessary adjustment procedures to follow after the instrument has been repaired.

5-13. ADJUSTMENT LOCATIONS

5-14. To help locate the appropriate adjustment points, the locations of the components to be adjusted are illustrated throughout the adjustment procedures. The locations of factory selected components, connectors, and other components related to the adjustments are shown in the individual board assembly-component illustrations (fold-out service sheets) in Section VIII.

5-15. INITIAL OPERATING PROCEDURE

5-16. Before proceeding with the adjustments described starting in paragraph 5-17, perform the following preliminary procedure. This procedure provides access to the various adjustment points and facilitates a thoroughgoing adjustment.

[BASIC OPERATING CHECK]

Check that the instrument's line voltage selector switch, located on the rear panel, is set to the position appropriate for the local line voltage. This should be performed before proceeding with any of the adjustments.

After the recommended 30-minute warm-up period, the instrument should pass the SELF TEST (no error message should appear). If the instrument displays an error message or does not have the correct control settings, refer to the troubleshooting procedures given in Section VIII.

[TOP COVER REMOVAL]

- a. Fully loosen the top-cover retaining screw located at the rear of the top cover.
- b. Slide the top cover towards the rear and lift off.

WARNING

DC VOLTAGES—MAXIMUM $\pm 16V$ —ARE PRESENT AT TEST POINTS ON THE A1, A2, AND A4 BOARDS. AS A SAFETY PRECAUTION AGAINST POSSIBLE ELECTRICAL SHOCK HAZARDS AND RESULTANT INJURY, USE INSULATED TOOLS FOR ALL ADJUSTMENTS.

Note

1. To select a numbered SELF TEST:
 - a) Press the SELF TEST key and the FREQUENCY/DC BIAS Select key in order.
 - b) The number displayed on the FREQUENCY/DC BIAS DISPLAY is the SELF TEST number.
 - c) The SELF TEST number can be changed by pressing the FREQUENCY/ DC BIAS Step Control Key.
2. To obtain initial control settings (erase continuous memory):
 - a) Turn off the instrument.
 - b) Press and hold both FREQUENCY/DC BIAS Step Control keys (Ⓢ and Ⓣ).
 - c) Turn on the instrument.
 - d) Release both FREQUENCY/DC BIAS Step Control Keys after the displays appears.

Table 5-2. Factory Selected Components

| Reference Designator | Nominal Value Range | Effect on Performance |
|------------------------|---|--|
| A2 R58 (Para. 5-19) | HP P/N: 0757-0278 , R: FXD 1.78k Ω ▶HP P/N: 0698-0084 , R: FXD 2.15k Ω HP P/N: 0698-0085 , R: FXD 2.61k Ω | Changes test signal level. If signal level is too high, use more resistance; if too low, use less resistance. |
| A2 C72 (Para. 5-21) | ▶HP P/N: 0160-5597 , C: FXD 5pF HP P/N: 0160-5593 , C: FXD 12pF | Compensates for junction capacitance of FET switch. If [DISP A] <72, remove C72; if [DISP A] >88, use more capacitance. |
| A2 C14 (Para. 5-22) | HP P/N: 0140-0191 , C: FXD 56pF ▶HP P/N: 0160-2202 , C: FXD 75pF HP P/N: 0160-2204 , C: FXD 100pF HP P/N: 0140-0196 , C: FXD 150pF | Eliminates phase offset in the AF attenuator. If [DISP B] <-4, use more capacitance; if [DISP B] >+4, use less capacitance. |
| A2 C15 (Para 5-22) | HP P/N: 0160-4794 , C: FXD 5.6pF ▶HP P/N: 0160-4789 , C: FXD 15pF HP P/N: 0160-4787 , C: FXD 22pF | Eliminates phase offset in the AF attenuator. If [DISP B] <-4, use more capacitance; if [DISP B] >+4, use less capacitance. |
| A2 C16 (Para 5-22) | HP P/N: 0160-2204 , C: FXD 100pF ▶HP P/N: 0140-0196 , C: FXD 150pF HP P/N: 0140-0198 , C: FXD 200pF | Eliminates phase offset in the AM2 attenuator. If [DISP B] <-4, use less capacitance; if [DISP B] >+4, use more capacitance. |
| A2 R93 (Para. 5-23) | HP P/N: 0757-0463 , R: FXD 82.5k Ω ▶HP P/N: 0757-0464 , R: FXD 90.9k Ω HP P/N: 0757-0465 , R: FXD 100k Ω | Compensates for buffer amplifier phase offset. If [DISP B] <-1, use more resistance; if [DISP B] >+1, use less resistance. |
| A2 C55 (Para. 5-23) | HP P/N: 0160-4806 , C: FXD 39pF ▶HP P/N: 0160-4803 , C: FXD 68pF HP P/N: 0160-4801 , C: FXD 100pF | Compensates for buffer amplifier phase offset. If [DISP B] <-1, use more capacitance; if [DISP B] >+1, use less capacitance. |
| A2 C5 (Para. 5-25) | HP P/N: 0160-4795 , C: FXD 4.7pF ▶HP P/N: 0160-4788 , C: FXD 18pF HP P/N: 0160-4786 , C: FXD 27pF HP P/N: 0160-4806 , C: FXD 39pF HP P/N: 0160-4804 , C: FXD 56pF | Eliminates phase offset of range resistor. If [DISP B] <-2, use less capacitance; if [DISP B] >+2, use more capacitance. |
| A2 C4 (Para. 5-25) | HP P/N: 0160-4795 , C: FXD 4.7pF ▶HP P/N: 0160-4791 , C: FXD 10pF HP P/N: 0160-4789 , C: FXD 15pF HP P/N: 0160-4787 , C: FXD 22pF | Eliminates phase offset of range resistor. If [DISP B] <-2, use less capacitance; if [DISP B] >+2, use more capacitance. |

Note: ▶ indicates the component usually used.

Table 5-3. Adjustment Requirements

| Assembly Repaired or Replaced | Required Adjustments |
|-------------------------------|--|
| A1 (04276-66501) | Para. 5-17 and 5-18 |
| A2 (04276-66502) | Para. 5-19 through 5-25 |
| A4 (04276-66504) | Para. 5-17 and 5-18 |
| A5 (04276-66505) | None |
| A6 (04276-66506) | None |
| A21 (04276-66521) | None |
| A22 (04276-66522) | Para. 5-17, 5-18 and 5-26 (only if A22 is added or removed) |
| 16064A A2 (16064-66502) | Para. 5-17 and 5-18 (only if 16064 A A2 is added or removed) |

ADJUSTMENTS

5-17. **A4 POWER SUPPLY ADJUSTMENT**

PURPOSE:

Adjusts the output voltages and the switching frequency of the switching power supply.

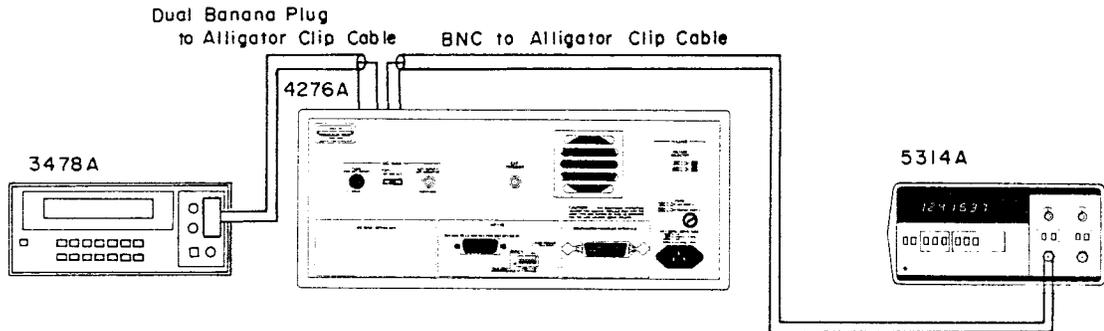


Figure 5-1. A4 Power Supply Adjustment Setup.

EQUIPMENT:

- Digital Voltmeter HP 3478A
- Frequency Counter HP 5314A
- BNC-to-Alligator Clip Cable HP 11000A
- Dual Banana Plug-to-Alligator Clip Cable HP 11002

PROCEDURE:

1. Connect the 3478A HI and LOW inputs to A4TP1 (+5V DIG) and A4TP2 (DIG GND), respectively, with the dual banana plug-to-alligator clip cable as shown in Figure 5-1.
2. Set the 3478A function to DCV.
3. Turn on the 4276A.
4. Adjust A4R14 (V-ADJ) until the reading on the 3478A is $+5.10V \pm 0.01V$.
5. Connect the 3478A LOW input to A4TP10 (GND).
6. Verify that the voltages at A4TP5 (+16V)/TP6(-16V)/TP7(+8V) are within test limits in the table below:

| Test Point | Test Limits |
|--------------|--------------|
| A4TP5 (+16V) | +15V to +17V |
| A4TP6 (-16V) | -15V to -17V |
| A4TP7 (+8V) | +8V to +10V |

7. Connect the 5314A to A4TP9 (DIG PWM) and A4TP10 (GND) with a BNC-to-alligator clip cable as shown in Figure 5-1.
8. Adjust A4R15 (F-ADJ) until the reading on the 5314A is $21kHz \pm 0.1kHz$.

Note

If necessary, adjust the trigger level on the 5314A.

ADJUSTMENTS

5-18. **A1 RESET VOLTAGE ADJUSTMENT**

PURPOSE:

Adjusts the threshold voltage for instrument reset to +4.80V.

Note

Perform the adjustment described in paragraph 5-17 before performing this adjustment.

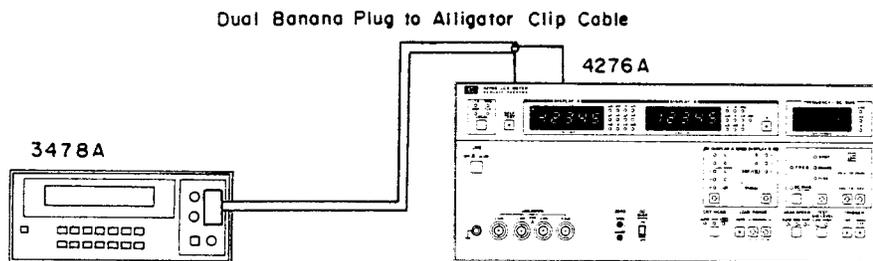


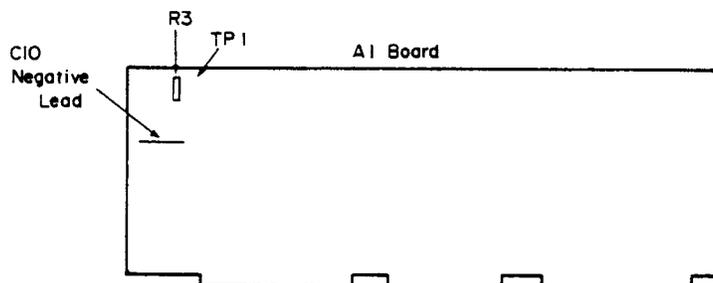
Figure 5-2. A1 Reset Voltage Adjustment Setup.

EQUIPMENT:

Digital Voltmeter HP 3478A
 Dual Banana Plug-to-Alligator Clip Cable..... HP 11002A

PROCEDURE:

1. Connect the HI and LOW inputs of the 3478A to A1TP1 and the negative lead of A1C10, respectively, with a dual banana-to-alligator clip cable as shown in Figure 5-2.
2. Set the 3478A function to DCV.
3. Turn on the 4276A.
4. Adjust A1R3 fully CCW.
5. Adjust A4R14 (V-ADJ) until the reading on the 3478A is +4.80V±0.02V.
6. Gradually adjust A1R3 CW until the 4276A display lamps go on and off.



ADJUSTMENTS

[Reset Voltage Level Check]

7. Adjust A4R14 (V-ADJ) until the reading on the 3478A is +5V.
8. Gradually adjust A4R14 (V-ADJ) until the reading on the 3478A is +4.83V. Verify that the 4276A display lamps have not gone off.
9. Gradually adjust A4R14 (V-ADJ) until the reading on the 3478A is +4.77V. Verify that the 4276A display lamps have gone on and off.
10. If the state of display lamps is different from the state described in steps 8. and 9., repeat steps 3. through 9.
11. Adjust A4R14 (V-ADJ) until the reading on the 3478A is +5.10V±0.02V.

Note

When the Comparator/Handler Interface board assembly (HP P/N 16064-66502) has been installed, connect the model 16064A to the connector on the rear panel before making this adjustment.

5-19. A2 TEST SIGNAL LEVEL ADJUSTMENT

PURPOSE:

Adjusts the test signal level.

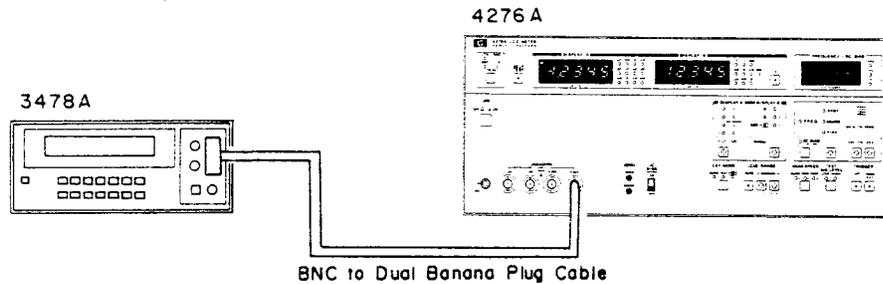


Figure 5-3. A2 Test Signal Level Adjustment Setup.

EQUIPMENT:

- Digital Voltmeter HP 3478A
- BNC-to-Dual Banana Plug Cable HP 11000A

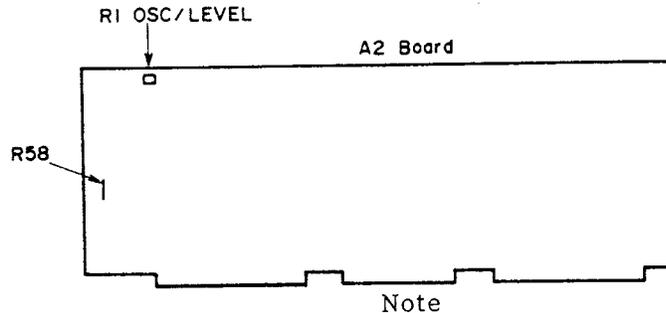
PROCEDURE:

1. Connect the 3478A to the 4276A H_{CUR} terminal with a BNC-to dual banana plug cable, as shown in Figure 5-3.
2. Set the 3478A function to ACV.
3. Turn on the 4276A and set the controls as follows:

- DISPLAY A/B functions C-ESR/G
- Test Frequency 1.00kHz
- DC BIAS OFF
- LC | Z | RANGE 100nF
- TEST SIG LEVEL HIGH
- Other Controls Any Settings

ADJUSTMENTS

4. Adjust A2R1 (OSC/LEVEL) until the reading on the 3478A is $1V_{rms} \pm 10mV_{rms}$.
5. Set the test signal level to LOW, and verify that the reading on the 3478A is $50mV_{rms} \pm 10mV_{rms}$.



If this adjustment cannot be performed successfully, replace A2R58 in accordance with the instructions given in Table 5-2.

5-20. **A2 DC OFFSET ADJUSTMENT**

PURPOSE:

Eliminates residual dc offset voltages from amplifier output voltages on the A2 board.

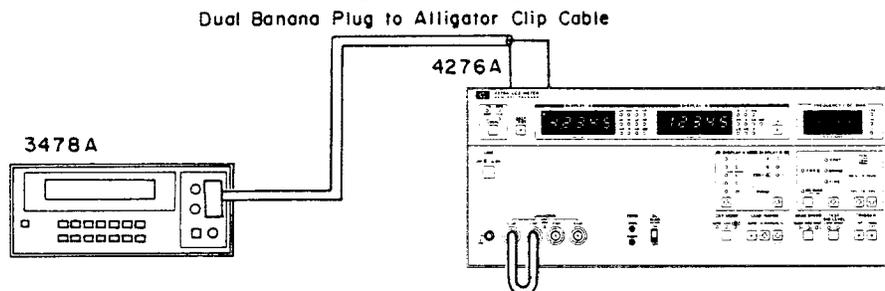


Figure 5-4. A2 DC Offset Adjustment Setup.

EQUIPMENT:

| | | |
|--|-----------|--------------------------------------|
| Digital Voltmeter | HP 3478A | } HP 16074A Standard Resistor Set |
| Terminations | OPEN | |
| | SHORT | |
| Dual Banana Plug-to-Alligator Clip Cable | HP 11002A | |

PROCEDURE:

1. Connect the 4276A's L_{CUR} and L_{POT} terminals to each other with a BNC-to-BNC cable.

[Differential Amplifier and Process Amplifier DC Offset Adjustment]

2. Connect the 3478A HI and LOW inputs to A2TP7 (PD/IN) and A2TP4 (GND), respectively, as shown in Figure 5-4.
3. Set the 3478A function to DCV.
4. Turn on the 4276A.
5. Set the 4276A to SELF TEST 16. (Refer paragraph 5-15 for the procedure.)
6. Adjust A2R17 (DIF/OFS) until the reading on the 3478A is $0V \pm 0.2mV$.

ADJUSTMENTS

[AM-1 Amplifier DC Offset Adjustment]

7. Connect the 3478A HI input to A2TP8 (AM1).
8. Adjust A2R25 (AM1/OFS) until the reading on the 3478A is $0V \pm 0.5mV$.

[AF Amplifier DC Offset Adjustment]

9. Connect the 3478A HI input to A2TP9 (AF).
10. Adjust A2R39 (AF/OFS) until the reading on the 3478A is $0V \pm 1mV$.

[AM-2 Amplifier DC Offset Adjustment]

11. Connect the 3478A HI input to A2TP10 (PD/IN).
12. Adjust A2R40 (AM2 OFS) until the reading on the 3478A is $0V \pm 5mV$.

[I/V Amplifier DC Offset Adjustment]

13. Set the 4276A to SELF TEST 17. (Refer to paragraph 5-15 for the procedure.)
14. Connect the 3478A HI input to A2TP5 (I/V OUT).
15. Adjust A2R16 (LC/OFS) until the reading on the 3478A is $0V \pm 0.5mV$.

[Err Buffer Amplifier DC Offset Adjustment]

16. Connect the 3478A HI input to A2TP7 (VRD/IN).
17. Adjust A2R13 (ER/OFS) until the reading on the 3478A is $0V \pm 0.2mV$.

[HPOT Buffer Amplifier DC Offset Adjustment]

18. Set the 4276A to SELF TEST 18. (Refer to paragraph 5-15 for the procedure.)
19. Adjust A2R15 (ED/OFS) until the reading on the 3478A is $0V \pm 0.2mV$.
20. Press the SELF TEST key to release the self test mode.

| Procedure | SELF TEST Number | Digital Voltmeter Inputs | | Adjustment Component | Limit |
|-----------|------------------|--------------------------|-------------|----------------------|---------------|
| | | HI | LO | | |
| (1) | 16 | A2TP7 (VRD/IN) | A2TP4 (GND) | A2R17 (DIF/OFS) | $0 \pm 0.2mV$ |
| (2) | 16 | A2TP8 (AM1) | A2TP4 (GND) | A2R25 (AM1/OFS) | $0 \pm 0.5mV$ |
| (3) | 16 | A2TP9 (AF) | A2TP4 (GND) | A2R39 (AF/OFS) | $0 \pm 1mV$ |
| (4) | 16 | A2TP10 (PD/IN) | A2TP4 (GND) | A2R40 (AM2 OFS) | $0 \pm 5mV$ |
| (5) | 17 | A2TP5 (IV OUT) | A2TP4 (GND) | A2R16 (LC/OFS) | $0 \pm 0.5mV$ |
| (6) | 17 | A2TP7 (VRD IN) | A2TP4 (GND) | A2R13 (ER/OFS) | $0 \pm 0.2mV$ |
| (7) | 18 | A2TP7 (VRD IN) | A2TP4 (GND) | A2R15 (ED/OFS) | $0 \pm 0.2mV$ |

Note

Use a BNC-to-BNC coaxial cable to interconnect the L_{cur} and L_{pot} UNKNOWN terminals.

ADJUSTMENTS

[[DC Offset Check]]

[SHORT Offset Check]

1. Set the 4276A's controls as follows:

| | |
|-----------------------------|----------------|
| DISPLAY A/B functions | Z - θ |
| Test Frequency | 1.00kHz |
| DC BIAS | OFF |
| LC Z RANGE | 100m Ω |
| MEAS SPEED | MED |
| TRIGGER | INT |
| Other Controls | Any Settings |

2. Connect the 3478A HI and LOW inputs to A2TP10 (PD/IN) and A2TP4 (GND), respectively, with a dual banana plug-to-alligator clip cable.
3. Set the 4276A to SELF TEST 23. (Refer to paragraph 5-15 for the procedure.)
4. Press the MAN/EXT key on the front-panel once.
5. Connect the SHORT termination to the UNKNOWN terminals.
6. Verify that the reading on the 3478A is 0mV \pm 100mV.

[OPEN Offset Check]

7. Press the SELF TEST key to release the self test mode.
8. Set the 4276A's controls as follows:

| | |
|-----------------------------|-------------|
| DISPLAY A/B functions | C - D |
| Test Frequency | 5.00kHz |
| DC BIAS | OFF |
| CKT MODE | Any Setting |
| LC Z RANGE | 10pF |
| MEAS SPEED | MED |
| TEST SIG LEVEL | LOW |
| TRIGGER | INT |

9. Set the 4276A to SELF TEST 23.
10. Press MAN/EXT key on the front-panel once.
11. Connect the OPEN termination to the UNKNOWN terminals.
12. Verify that the reading on the 3478A is 0mV \pm 100mV.

Note

If the SHORT and OPEN Offset checks cannot be performed successfully, repeat steps 1 through 20 of the main procedure.

ADJUSTMENTS

5-21. **A2 ADC ZERO ADJUSTMENT**

PURPOSE:

Eliminates residual dc offset voltage from the integrator output.

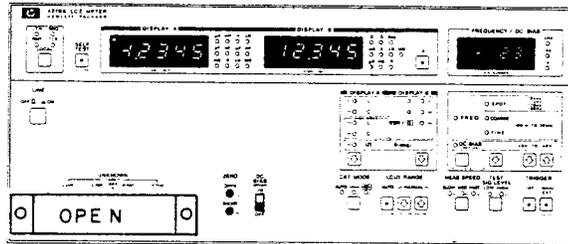


Figure 5-5. A2 ADC Zero Adjustment Setup.

Note

DO NOT extend A2 board assembly in this adjustment.

EQUIPMENT:

Termination OPEN: HP 16074A

PROCEDURE:

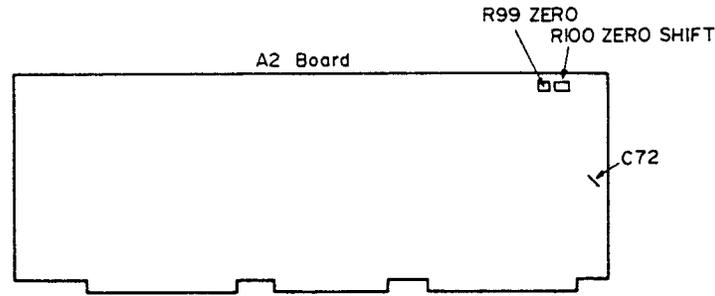
1. Turn on the 4276A.
2. Connect the OPEN termination of the 16074A directly to the UNKNOWN terminals.
3. Set the 4276A's controls as follows:
 - Test Frequency 1.00kHz
 - DC BIAS OFF
 - MEAS SPEED MED
 - TEST SIG LEVEL HIGH
 - TRIGGER INT
 - Other Controls Any setting
4. Set the 4276A to SELF TEST 8. (Refer to paragraph 5-15 for the procedure.)
5. Set A2R100 (ZERO SHIFT) at the midway point.
6. Adjust A2R99 (ZERO) until [A] equals - [B].

Note

[A] and [B] are defined as the values displayed on DISPLAY A and DISPLAY B, respectively.

7. Adjust A2R100 (ZERO SHIFT) until
 - [A] = 20 counts±1 count and [B] = -20 counts±1 count.
8. Set the measurement speed mode to FAST. Verify that
 - [A] = 80 counts±8 count and [B] = -80 counts±8 counts.

ADJUSTMENTS



Note

If the test in step 8 cannot be performed successfully, replace A2C72 in accordance with the instructions given in Table 5-2.

5-22. A2 AM/AF ATTENUATOR ADJUSTMENT

PURPOSE:

Adjusts the attenuation and phase of the attenuators in the AM and AF circuits.

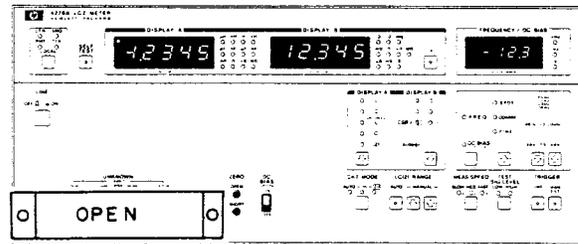


Figure 5-6. A2 AM/AF Attenuator Adjustment Setup.

EQUIPMENT:

Termination OPEN: HP 16074A

PROCEDURE:

1. Connect the OPEN termination of the 16074A directly to the UNKNOWN terminals.
2. Turn on the 4276A.
3. Set the 4276A's controls as follows:

| | |
|----------------------|--------------|
| Test Frequency | 1.00kHz |
| DC BIAS | OFF |
| MEAS SPEED | SLOW |
| TEST SIG LEVEL | HIGH |
| TRIGGER | INT |
| Other Controls | Any settings |

ADJUSTMENTS

[AF 1/2 Attenuator Adjustment]

4. Set the 4276A to SELF TEST 12. (Refer to paragraph 5-15 for the procedure.)
5. Adjust A2R26 (AF 1/2) until [A] is 0 counts \pm 4 counts. Verify that [B] is 0 count \pm 10 counts.

Note

[A] and [B] are defined as the values displayed on DISPLAY A and DISPLAY B, respectively.

[AF 1/5 Attenuator Adjustment]

6. Set the 4276A to SELF TEST 13.
7. Adjust A2R27 (AF 1/5) until [A] is 0 counts \pm 4 counts. Verify that [B] is 0 counts \pm 10 counts.

[AM2 1/10 Attenuator Adjustment]

8. Set the 4276A to SELF TEST 14.
9. Adjust A2R35 (AM 1/10) until [A] is 0 counts \pm 4 counts. Verify that [B] is 0 counts \pm 10 counts.

[AM1 Attenuator Check]

10. Set the 4276A to SELF TEST 15.
11. Verify that [A] and [B] are 0 counts \pm 40 counts and 0 counts \pm 15 counts, respectively.

[VRD Full Scale Check]

12. Press the SELF TEST key to release the SELF TEST mode.
13. Set the test frequency to 20kHz.
14. Set the 4276A to SELF TEST 9
15. Verify that [A] and [B] are 0 counts \pm 20 counts and 0 counts \pm 10 counts, respectively.

[AF 1/2 Attenuator Phase Adjustment]

16. Set the 4276A to SELF TEST 12.
17. Adjust A2C12 (PH 1/2) until [B] is 0 counts \pm 20 counts. Verify that [A] is 0 counts \pm 4 counts.

Note

If this adjustment cannot be performed successfully, replace A2C14 in accordance with the instructions given in described in Table 5-2.

ADJUSTMENTS

[AF 1/5 Attenuator Phase Adjustment]

18. Set the 4276A to SELF TEST 13.
19. Adjust A2C13 (PH 1/5) until [B] is 0 counts \pm 4 counts. Verify that [A] is 0 counts \pm 20 counts.

Note

If this adjustment cannot be performed successfully, replace A2C15 in accordance with the instructions given in Table 5-2.

[AM2 1/10 Attenuator Phase Adjustment]

20. Set the 4276A to SELF TEST 14.
21. Adjust A2C18 (PH 1/10) until [B] is 0 counts \pm 4 counts. Verify that [A] is 0 counts \pm 40 counts.

Note

If this adjustment cannot be performed successfully, replace A2C16 in accordance with the instructions given in Table 5-2.

[AM1 Attenuator Phase Check]

22. Set the 4276A to SELF TEST 15.
23. Verify that [A] and [B] are 0 counts \pm 120 counts and 0 counts \pm 200 counts, respectively.

| Procedure | SELF TEST Number | Test Frequency | Adjustment Component | Adjustment Limit (counts) | | Check Limit (counts) | |
|-----------|------------------|----------------|----------------------|---------------------------|-----------|----------------------|-------------|
| | | | | DISPLAY A | DISPLAY B | DISPLAY A | DISPLAY B |
| (1) | 12 | 1kHz | A2R26 (AF 1/2) | 0 \pm 4 | | | 0 \pm 10 |
| (2) | 13 | 1kHz | A2R29 (AF 1/5) | 0 \pm 4 | | | 0 \pm 10 |
| (3) | 14 | 1kHz | A2R35 (AM 1/10) | 0 \pm 4 | | | 0 \pm 10 |
| (4) | 15 | 1kHz | | | | 0 \pm 40 | 0 \pm 15 |
| (5) | 9 | 20kHz | | | | 0 \pm 20 | 0 \pm 10 |
| (6) | 12 | 20kHz | A2C12 (PH 1/2) | | 0 \pm 4 | 0 \pm 20 | |
| (7) | 13 | 20kHz | A2C13 (PH 1/5) | | 0 \pm 4 | 0 \pm 20 | |
| (8) | 14 | 20kHz | A2C18 (PH 1/10) | | 0 \pm 4 | 0 \pm 40 | |
| (9) | 15 | 20kHz | | | | 0 \pm 120 | 0 \pm 200 |

ADJUSTMENTS

5-23. **A2 LF/HF TRACKING ADJUSTMENT**

PURPOSE:

Compensates for the difference between the phase shift caused by the Err circuit and the phase shift caused by the Edut circuit in the low frequency (LF) and high frequency (HF) ranges.

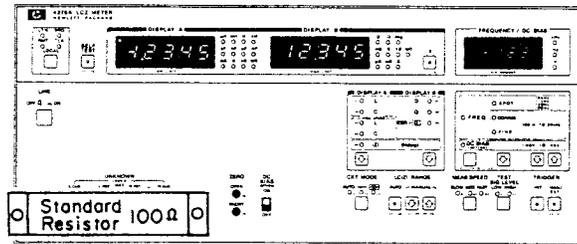


Figure 5-7. A2 LF/HF Tracking Adjustment Setup.

EQUIPMENT:

Standard Resistor 100Ω: HP 16074A
Standard Resistor Set

PROCEDURE:

[LF Adjustment]

1. Connect the 100Ω standard resistor directly to the UNKNOWN terminals.
2. Reset continuous memory (see Note 2 in paragraph 5-15) and turn on the 4276A.
3. Set the 4276A's controls as follows:

| | |
|-----------------------------|----------------|
| DISPLAY A/B functions | Z - θ |
| Test Frequency | 100Hz |
| DC BIAS | OFF |
| CKT MODE | Any Setting |
| LC Z RANGE | 1kΩ |
| MEAS SPEED | MED |
| TEST SIG LEVEL | HIGH |
| TRIGGER | INT |

4. Set the 4276A to SELF TEST 2. (Refer to paragraph 5-15 for the procedure.)
5. Adjust A2R14 (LF TRK) until the 4276A displays 0 counts±1 count on DISPLAY B.

Note

If this adjustment cannot be performed successfully, replace A2R93 in accordance with the instructions given in Table 5-2.

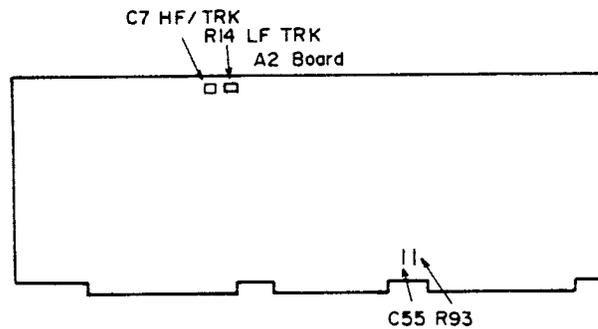
ADJUSTMENTS

[HF Adjustment]

6. Press the SELF TEST key to release the SELF TEST mode.
7. Set the test frequency to 20kHz.
8. Set the 4276A to SELF TEST 2.
9. Adjust A2C7 (HF/TRK) until the 4276A displays 0 counts±1 count on DISPLAY B.

Note

If this test cannot be performed successfully, replace A2C55 in accordance with instructions given in Table 5-2.



5-24. A2 RANGE RESISTOR MAGNITUDE ADJUSTMENT

PURPOSE:

Adjusts the range resistor values.

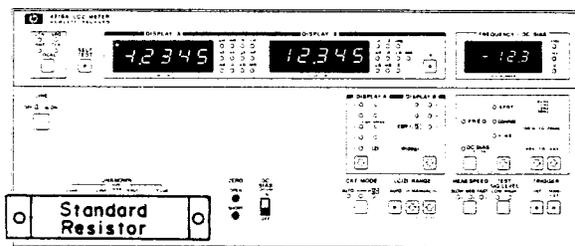


Figure 5-8. A2 Range Resistor Magnitude Adjustment Setup.

EQUIPMENT:

- | | | |
|--------------------------|-------|--------------------------------------|
| Standard Resistors | 100Ω | } HP 16074A Standard Resistor Set |
| | 1kΩ | |
| | 10kΩ | |
| | 100kΩ | |

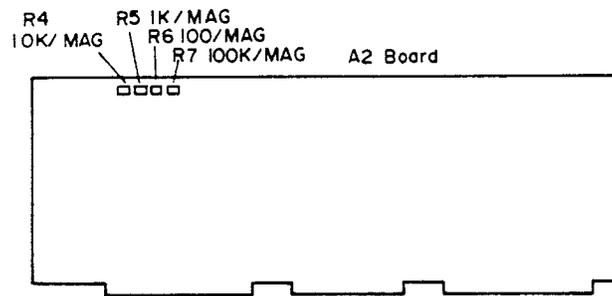
ADJUSTMENTS

PROCEDURE:

1. Calculate the reciprocal of the calibrated values of the 100Ω/1kΩ/10kΩ and 100kΩ standard resistors; [1/c.v.].
2. Reset continuous memory (see Note 2 in paragraph 5-15).
3. Connect the 100kΩ standard resistor directly to the UNKNOWN terminals.
4. Set the 4276A's controls as follows:

| | |
|-----------------------------|-------------|
| DISPLAY A/B functions | Z - θ |
| Test Frequency | 1.00kHz |
| DC BIAS | OFF |
| CKT MODE | Any Setting |
| LC Z RANGE | 1MΩ |
| MEAS SPEED | MED |
| TEST SIG LEVEL | HIGH |
| TRIGGER | INT |

5. Set the 4276A to SELF TEST 2. (Refer to paragraph 5-15 for the procedure.)



[100K/MAG Adjustment]

6. Adjust A2R7 (100K/MAG) until the 4276A displays [1/c.v.]±1 count on DISPLAY A. Verify that the DISPLAY B value is 0±10 counts.

Note

The units for both DISPLAY A and DISPLAY B values are μS.

[10K/MAG Adjustment]

7. Set the DISPLAY A range to the 100μS range. (Use the LC | Z | RANGE key.)
8. Connect the 10kΩ standard resistor directly to the UNKNOWN terminals.
9. Adjust A2R4 (10k/MAG) until the 4276A displays [1/c.v.] ±1 count on DISPLAY A. Verify that the DISPLAY B value is 0±5 counts.

[1K/MAG Adjustment]

10. Set the DISPLAY A range to the 1mS range.
11. Connect the 1kΩ standard resistor directly to the UNKNOWN terminals.
12. Adjust A2R5 (1K/MAG) until the 4276A displays [1/c.v.]±1 count on DISPLAY A. Verify that the DISPLAY B value is 0±5 counts.

ADJUSTMENTS

4. Adjust A2C3 (100K/PH) until the 4276A displays 0 counts \pm 2 counts on DISPLAY B. Verify that the 4276A displays C.V. \pm 30 counts on DISPLAY A.

Note

If this test cannot be performed successfully, replace A2C5 in accordance with the instructions given in Table 5-2.

5. Connect the 1000pF standard capacitor directly to the UNKNOWN terminals.
6. Adjust A2C2 (10K/PH) until the 4276A displays 0 counts \pm 2 counts on DISPLAY B. Verify that the 4276A displays C.V. \pm 30 counts on DISPLAY A.

Note

If this test cannot be performed successfully, replace A2C4 in accordance with the instructions given in Table 5-2.

ADJUSTMENTS

5-26. **INTERNAL DC BIAS ADJUSTMENT (OPTION 001 ONLY)**

PURPOSE:

Adjusts the output voltage of the internal dc bias voltage source.

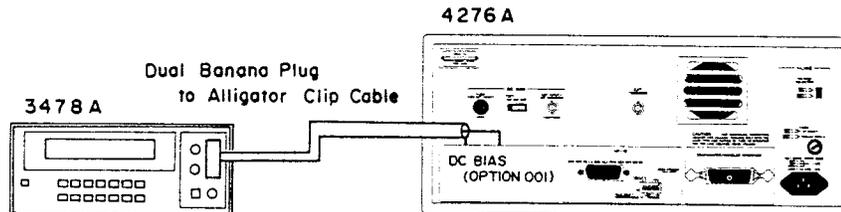


Figure 5-10. Internal DC Bias Adjustment Setup.

EQUIPMENT:

| | |
|-------------------------|--------------------|
| Digital Voltmeter | HP 3478A |
| Extender Board | HP P/N 04276-66562 |

PROCEDURE:

1. Extend the A22 DC BIAS board from the rear-panel with the extension board.
2. Set the DC BIAS select switch on the rear panel to INT.
3. Turn on the 4276A.
4. Set the DC BIAS switch on the front panel to ON.
5. Set the 3478A function to DCV.
6. Connect the 3478A HI and LOW inputs to A22TP2 and A22 GND, respectively.
7. Adjust A22R8 until the reading on the 3478A is $0V \pm 0.05mV$.
8. Connect the 3478A HI input to A22TP3.
9. Adjust A22R6 (ZERO) until the reading on the 3478A is $0V \pm 0.2mV$.
10. Connect the 3478A HI input to the center conductor of the EXT INPUT/INT MONITOR connector on the rear panel.
11. Set the dc bias voltage to +9.99V.
12. Adjust A22R7 (FS) until the reading on the 3478A is $+9.99V \pm 0.002V$.

SECTION VI REPLACEABLE PARTS

6-1. INTRODUCTION

6-2. This section contains information for ordering parts. Table 6-1 lists abbreviations used in the parts list and throughout the manual. Table 6-3 lists all replaceable parts in reference designator order. Table 6-2 contains the names and addresses that correspond to the manufacturer's code numbers.

6-3. ABBREVIATIONS

6-4. Table 6-1 lists abbreviations used in parts list, schematics and throughout the manual. In some cases, two forms of abbreviations are used, one in all capital letters, and one in partial capitals or no capitals. This occurs because the abbreviations in parts list are always all capitals. However, in the schematic and in other parts of the manual, other abbreviation forms with both lower case and upper case letters are used.

6-5. REPLACEABLE PARTS LIST

6-6. Table 6-3 is a list of replaceable parts and is organized as follows :

- a. Electrical assemblies and their components in alphanumerical order by reference designation.
- b. Chassis-mounted parts in alphanumerical order by reference designation.
- c. Miscellaneous parts.
- d. Illustrated parts breakdowns, if appropriate.

The information for each part includes :

- a. The Hewlett-Packard part number.
- b. The total quantity (Qty) in the instrument.
- c. A description of the part.
- d. A typical manufacturer of the part in a five-digit code.
- e. The manufacturer's number for the part.

Table 6-1. List of Reference Designators and Abbreviations

| REFERENCE DESIGNATORS | | | |
|---|--|--|--|
| A = assembly B = motor BT = battery C = capacitor CP = coupler CR = diode DL = delay line DS = device signaling (lamp) | E = misc electronic part F = fuse FL = filter J = jack K = relay L = inductor M = meter MP = mechanical part | P = plug Q = transistor R = resistor RT = thermistor S = switch T = transformer TB = terminal board TP = test point | U = integrated circuit V = vacuum, tube, neon bulb, photocell, etc. VR = voltage regulator W = cable X = socket Y = crystal |
| ABBREVIATIONS | | | |
| A = amperes A. F. C. = automatic frequency control AMPL = amplifier B. F. O. = beat frequency oscillator BE CU = beryllium copper BH = binder head BP = bandpass BRS = brass BWO = backward wave oscillator CCW = counter-clockwise CER = ceramic CMO = cabinet mount only COEF = coefficient COM = common COMP = composition COMPL = complete CONN = connector CP = cadmium plate CRT = cathode-ray tube CW = clockwise DEPC = deposited carbon DR = drive ELECT = electrolytic ENCAP = encapsulated EXT = external F = farads f = femto = 10 ⁻¹⁵ FH = flat head FIL H = filister head FXD = fixed G = giga = 10 ⁹ GE = germanium GL = glass GRD = grounded | H = henries HEX = hexagonal HG = mercury HR = hour(s) Hz = hertz IF = intermediate freq. IMPG = impregnated INCD = incandescent INCL = include(s) INS = insulation(ed) INT = internal k = kilo = 1000 LH = left hand LIN = linear taper LK WASH = lock washer LOG = logarithmic taper LPP = low pass filter m = milli = 10 ⁻³ M = meg = 10 ⁶ MET FLM = metal film MET OX = metallic oxide MFR = manufacturer MINAT = miniature MOM = momentary MTG = mounting MY = "mylar" n = nano = 10 ⁻⁹ N C = normally closed NE = neon NI PL = nickel plate N O = normally open NPO = negative positive zero (zero temperature coefficient) | NPN = negative-positive-negative NRFR = not recommended for field replacement NSR = not separately replaceable OBD = order by description OH = oval head OX = oxide P = peak PC = printed circuit p = pico = 10 ⁻¹² PH BRZ = phosphor bronze PHL = Phillips PIV = peak inverse voltage PNP = positive-negative-positive P/O = part of POLY = polystyrene PORC = porcelain POS = position(s) POT = potentiometer PP = peak-to-peak PT = point PWV = peak working voltage RECT = rectifier RF = radio frequency RH = round head or right hand RMO = rack mount only RMS = root-mean square | RWV = reverse working voltage S-B = slow-blow SCR = screw SE = selenium SECT = section(s) SEMICON = semiconductor SI = silicon SIL = silver SL = slide SPG = spring SPL = special SST = stainless steel SR = split ring STL = steel TA = tantalum TD = time delay TGL = toggle THD = thread TI = titanium TOL = tolerance TRIM = trimmer TWT = traveling wave tube μ = micro = 10 ⁻⁶ VAR = variable VDCW = dc working volts W' = with W = watts WIV = working inverse voltage WW = wirewound W O = without |

0001-3700

SECTION VI

The total quantity for each part is given only once--at the first appearance of the part number in the list.

6-7. ORDERING INFORMATION

6-8. To order a part listed in the replaceable parts table, give the Hewlett-Packard part number, indicate the quantity required, and address the order to the nearest Hewlett-Packard office.

6-9. To order a part that is not listed in the replaceable parts table, state the full instrument model and serial number, and description and function of the part, and the number of parts required. Address your order to the nearest Hewlett-Packard office.

6-10. DIRECT MAIL ORDER SYSTEM

6-11. Within the USA, Hewlett-Packard can supply parts through a direct mail order system. Advantages of using the system are :

- a. Direct ordering and shipment from the HP Parts Center in Mountain View, California.
- b. No maximum or minimum on any mail order (there is a minimum order amount for parts ordered through a local HP Office when the orders require billing and invoicing).
- c. Prepaid transportation (there is a small handling charge for each order).
- d. No invoices--to provide these advantages, a check or money order must accompany each order.

6-12. Mail order forms and specific ordering information are available through your local HP Office. Addresses and phone numbers are located at the back of this manual.

Table 6-2. Manufacturers Code Lists

| MFR NO. | MANUFACTURER NAME | ADDRESS | ZIP CODE |
|---------|------------------------------------|------------------|----------|
| 00000 | ANY SATISFACTORY SUPPLIER | | |
| 01121 | ALLEN-BRADLEY CO | MILWAUKEE WI | 53204 |
| 01295 | TEXAS INSTR INC SEMICOND CMPNT DIV | DALLAS TX | 75222 |
| 02111 | SPECTROL ELECTRONICS CORP | CITY OF IND CA | 91745 |
| 03508 | GE CO SEMICONDUCTOR PROD DEPT | AUBURN NY | 13201 |
| 03888 | K D I PYROFILM CORP | WHIPPANY NJ | 07981 |
| 04713 | MOTOROLA SEMICONDUCTOR PRODUCTS | PHOENIX AZ | 85008 |
| 05574 | VIKING INDUSTRIES INC | CHATSWORTH CA | 91311 |
| 07263 | FAIRCHILD SEMICONDUCTOR DIV | MOUNTAIN VIEW CA | 94042 |
| 14936 | GENERAL INSTR CORP SEMICON PROD GP | HICKSVILLE NY | 11802 |
| 24355 | ANALOG DEVICES INC | NORWOOD MA | 02062 |
| 24546 | CORNING GLASS WORKS (BRADFORD) | BRADFORD PA | 16701 |
| 27014 | NATIONAL SEMICONDUCTOR CORP | SANTA CLARA CA | 95051 |
| 27167 | CORNING GLASS WORKS (WILMINGTON) | WILMINGTON NC | 28401 |
| 28480 | HEWLETT-PACKARD CO CORPORATE HQ | PALO ALTO CA | 94304 |
| 3L585 | RCA CORP SOLID STATE DIV | SOMERVILLE NJ | |
| 30983 | MEPCO/ELECTRA CORP | SAN DIEGO CA | 92121 |
| 34649 | INTEL CORP | MOUNTAIN VIEW CA | 95051 |
| 52763 | STETTNER-TRUSH INC | CAZENOVIA NY | 13035 |
| 56289 | SPRAGUE ELECTRIC CO | NORTH ADAMS MA | 01247 |
| 72136 | ELECTRO MOTIVE CORP | FLORENCE SC | 06226 |
| 75042 | TRW INC PHILADELPHIA DIV | PHILADELPHIA PA | 19108 |
| 75915 | LITTELFUSE INC | DES PLAINES IL | 60016 |
| 98291 | SEAELECTRO CORP | MAMARONECK NY | 10544 |

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|------------------|
| A 1 | 04276-66501 | 0 | 1 | LOGIC BOARD ASSEMBLY | 28480 | 04276-66501 |
| A1C1 | 0180-1085 | 5 | 13 | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C2 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C3 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C4 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C5 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C6 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C7 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C8 | 0180-0197 | 8 | 1 | CAPACITOR-FXD 2.2UF+-10% 20VDC TA | 56289 | 150D225X9020A2 |
| C9 | 0160-4832 | 4 | 2 | CAPACITOR-FXD .01UF +-10% 100VDC CER | 28480 | 0160-4832 |
| C10 | 0180-3219 | 1 | 1 | CAPACITOR-FXD 2.2 UF 63VDC | 28480 | 0180-3219 |
| C11 | 0160-4801 | 7 | 1 | CAPACITOR-FXD 100PF +-5% 100VDC CER | 28480 | 0160-4801 |
| C12 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C13 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C14 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C15 | 0180-2951 | 6 | 1 | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C16 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C17 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C18 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C19 | 0160-4832 | 4 | | CAPACITOR-FXD .01UF +-10% 100VDC CER | 28480 | 0160-4832 |
| C20 | 0180-3217 | 9 | 2 | CAPACITOR-FXD 470UF | 28480 | 0180-3217 |
| C21 | 0180-3217 | 9 | | CAPACITOR-FXD 470UF | 28480 | 0180-3217 |
| A1CR1 | 1901-0539 | 3 | 2 | DIODE-SM SIG SCHOTTKY | 28480 | 1901-0539 |
| CR2 | 1901-0539 | 3 | | DIODE-SM SIG SCHOTTKY | 28480 | 1901-0539 |
| A1J1 | 1200-0607 | 0 | 2 | SOCKET-IC 16-CONT DIP DIP-SLDR | 28480 | 1200-0607 |
| J2 | 1200-0607 | 0 | | SOCKET-IC 16-CONT DIP DIP-SLDR | 28480 | 1200-0607 |
| J3 | 1200-0654 | 7 | 2 | SOCKET-IC 40-CONT DIP DIP-SLDR | 28480 | 1200-0654 |
| J4 | 1200-0541 | 1 | 10 | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J5 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J6 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J7 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J8 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J9 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J10 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J11 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J12 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J13 | 1200-0541 | 1 | | SOCKET-IC 24-CONT DIP DIP-SLDR | 28480 | 1200-0541 |
| J14 | 1200-0654 | 7 | | SOCKET-IC 40-CONT DIP DIP-SLDR | 28480 | 1200-0654 |
| A1Q1 | 1854-0810 | 2 | 3 | TRANSISTOR NPN SI PD=625MW FT=200MHZ | 28480 | 1854-0810 |
| Q2 | 1854-0810 | 2 | | TRANSISTOR NPN SI PD=625MW FT=200MHZ | 28480 | 1854-0810 |
| Q3 | 1853-0281 | 9 | 1 | TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW | 04713 | 2N2907A |
| Q4 | 1854-0810 | 2 | | TRANSISTOR NPN SI PD=625MW FT=200MHZ | 28480 | 1854-0810 |
| Q5 | 1853-0015 | 7 | 1 | TRANSISTOR PNP SI PD=200MW FT=500MHZ | 28480 | 1853-0015 |
| A1R1 | 1810-0488 | 8 | 1 | NETWORK-RES 8-SIP4.7K OHM X 4 | 28480 | 1810-0488 |
| R2 | 0757-0199 | 3 | 1 | RESISTOR 21.5K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2152-F |
| R3 | 2100-3103 | 6 | 1 | RESISTOR-TRMR 10K 10% C SIDE-ADJ 17-TRN | 02111 | 43P103 |
| R4 | 0757-0440 | 7 | 1 | RESISTOR 7.5K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-7501-F |
| R5 | 0683-2215 | 1 | 1 | RESISTOR 220 5% .25W FC TC=-400/+600 | 01121 | CB2215 |
| R6 | 0683-4715 | 0 | 1 | RESISTOR 470 5% .25W FC TC=-400/+600 | 01121 | CB4715 |
| R7 | 1810-0607 | 3 | 1 | RESISTIVE NETWORK- SIP | 28480 | 1810-0607 |
| R8 | 0683-1045 | 3 | 1 | RESISTOR 100K 5% .25W FC TC=-400/+800 | 01121 | CB1045 |
| R9 | 0683-2245 | 7 | 1 | RESISTOR 220K 5% .25W FC TC=-800/+900 | 01121 | CB2245 |
| R10 | 0683-1005 | 5 | 2 | RESISTOR 10 5% .25W FC TC=-400/+500 | 01121 | CB1005 |
| R11 | 0683-1025 | 9 | 2 | RESISTOR 1K 5% .25W FC TC=-400/+600 | 01121 | CB1025 |
| R12 | 0683-5605 | 9 | 1 | RESISTOR 56 5% .25W FC TC=-400/+500 | 01121 | CB5605 |
| R13 | 0683-0565 | 9 | 1 | RESISTOR 5.6 5% .25W FC TC=-400/+500 | | |
| R14 | 0683-1025 | 9 | | RESISTOR 1K 5% .25W FC TC=-400/+600 | 01121 | CB1025 |
| R15 | 1810-0305 | 8 | 5 | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R16 | 1810-0305 | 8 | | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R17 | 1810-0269 | 3 | 1 | NETWORK-RES 9-SIP10.0K OHM X 8 | 28480 | 1810-0269 |
| R18 | 1810-0305 | 8 | | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R19 | 1810-0305 | 8 | | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R20 | 1810-0305 | 8 | | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R21 | 0683-4725 | 2 | 5 | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| R22 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| R23 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| R24 | 0683-3325 | 6 | 1 | RESISTOR 3.3K 5% .25W FC TC=-400/+700 | 01121 | CB3325 |
| R25 | 0683-6825 | 7 | 1 | RESISTOR 6.8K 5% .25W FC TC=-400/+700 | 01121 | CB6825 |
| R26 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| R27 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A1S1 | 3101-1973 | 7 | 1 | SWITCH-SL 7-1A DIP-SLIDE-AGSY .1A 50VDC | 28480 | 3101-1973 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|-----------------|
| A1U1 | 1813-0291 | 7 | 1 | IC-CRYSTAL 11.52 M | 28480 | 1813-0291 |
| U2 | 1826-0978 | 4 | 1 | IC- (MISC) | 28480 | 1826-0978 |
| U3 | 1826-0180 | 0 | 1 | IC TIMER TTL MONO/ASTBL | 01295 | NE555P |
| U4 | 1820-2649 | 8 | 1 | IC- Z8008-CPU | 28480 | 1820-2649 |
| U5 | 04276-85001 | 5 | 1 | IC-PR0M, PROGRAMMED | 28480 | 04276-85001 |
| U6 | 04276-85002 | 6 | 1 | IC-PR0M, PROGRAMMED | 28480 | 04276-85002 |
| U7 | 04276-85003 | 7 | 1 | IC-PR0M, PROGRAMMED | 28480 | 04276-85003 |
| U8 | 04276-85004 | 8 | 1 | IC-PR0M, PROGRAMMED | 28480 | 04276-85004 |
| U9 | 04276-85005 | 9 | 1 | IC-PR0M, PROGRAMMED | 28480 | 04276-85005 |
| U10 | 04276-85006 | 0 | 1 | IC-PR0M, PROGRAMMED | 28480 | 04276-85006 |
| U12 | 1818-1974 | 5 | 1 | IC-MSM512B-15 | 28480 | 1818-1974 |
| U13 | 1820-2024 | 3 | 2 | IC DRVR TTL LS LINE DRVR OCTL | 01295 | SN74LS244N |
| U14 | 1820-2024 | 3 | | IC DRVR TTL LS LINE DRVR OCTL | 01295 | SN74LS244N |
| U15 | 1820-1730 | 6 | 1 | IC FF TTL LS D-TYPE POS-EDGE-TRIG COM | 01295 | SN74LS273N |
| U16 | 1820-1217 | 4 | 1 | IC MUXR/DATA-SEL TTL LS 8-TO-1-LINE | 01295 | SN74LS151N |
| U17 | 1820-1197 | 9 | 4 | IC GATE TTL LS NAND QUAD 2-INP | 01295 | SN74LS00N |
| U18 | 1820-1112 | 8 | 5 | IC FF TTL LS D-TYPE POS-EDGE-TRIG | 01295 | SN74LS74AN |
| U19 | 1820-1197 | 9 | | IC GATE TTL LS NAND QUAD 2-INP | 01295 | SN74LS00N |
| U20 | 1820-0682 | 5 | 1 | IC GATE TTL S NAND QUAD 2-INP | 01295 | SN74S03N |
| U21 | 1820-1197 | 9 | | IC GATE TTL LS NAND QUAD 2-INP | 01295 | SN74LS00N |
| U22 | 1820-1216 | 3 | 4 | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| U23 | 1820-1199 | 1 | 3 | IC INV TTL LS HEX 1-INP | 01295 | SN74LS04N |
| U24 | 1820-0681 | 4 | 1 | IC GATE TTL S NAND QUAD 2-INP | 01295 | SN74S00N |
| U25 | 1820-2150 | 6 | 1 | IC MICPROC-ACCESS NMOS | 34649 | D8279-5 |
| U26 | 1820-1216 | 3 | | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| U27 | 1820-1112 | 8 | | IC FF TTL LS D-TYPE POS-EDGE-TRIG | 01295 | SN74LS74AN |
| U28 | 1820-1112 | 8 | | IC FF TTL LS D-TYPE POS-EDGE-TRIG | 01295 | SN74LS74AN |
| U29 | 1820-1420 | 1 | 1 | IC CNTR TTL LS DIV-X-12 ASYNCHRO | 01295 | SN74LS92N |
| U30 | 1820-1432 | 5 | 2 | IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG | 01295 | SN74LS163AN |
| U31 | 1820-1432 | 5 | | IC CNTR TTL LS BIN SYNCHRO POS-EDGE-TRIG | 01295 | SN74LS163AN |
| U32 | 1820-1112 | 8 | | IC FF TTL LS D-TYPE POS-EDGE-TRIG | 01295 | SN74LS74AN |
| U33 | 1820-1199 | 1 | | IC INV TTL LS HEX 1-INP | 01295 | SN74LS04N |
| U34 | 1820-2075 | 4 | 1 | IC MISC TTL LS | 01295 | SN74LS245N |
| U35 | 1820-1216 | 3 | | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| U36 | 1820-1624 | 7 | 1 | IC BFR TTL S OCTL 1-INP | 01295 | SN74S241N |
| U37 | 1820-1199 | 1 | | IC INV TTL LS HEX 1-INP | 01295 | SN74LS04N |
| U38 | 1820-1197 | 9 | | IC GATE TTL LS NAND QUAD 2-INP | 01295 | SN74LS00N |
| U39 | 1820-2873 | 0 | 2 | IC-UPD8253-5 | 28480 | 1820-2873 |
| U40 | 1820-2873 | 0 | | IC-UPD8253-5 | 28480 | 1820-2873 |
| U41 | 1820-1216 | 3 | | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| U42 | 1820-1112 | 8 | | IC FF TTL LS D-TYPE POS-EDGE-TRIG | 01295 | SN74LS74AN |
| U43 | 1820-1425 | 6 | 1 | IC SCHMITT-TRIG TTL LS NAND QUAD 2-INP | 01295 | SN74LS132N |
| U44 | 1826-0122 | 0 | 1 | IC 7805 V RGLTR TO-220 | 07263 | 7805UC |
| A1W1 | 1251-4822 | 6 | 3 | CONNECTOR 3-PIN M POST TYPE | 28480 | 1251-4822 |
| W2 | 1251-4822 | 6 | | CONNECTOR 3-PIN M POST TYPE | 28480 | 1251-4822 |
| W3 | 1251-4822 | 6 | | CONNECTOR 3-PIN M POST TYPE | 28480 | 1251-4822 |
| W4 | 1251-4787 | 2 | 1 | SHUNT-DIP 8-POSITION | 28480 | 1251-4787 |
| | | | | MISCELLANEOUS PARTS | | |
| | 1258-0141 | 8 | 3 | JUMPER-REM | 28480 | 1258-0141 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|---------------------|
| A 2 | | | | | | |
| | 04276-66502 | 1 | 1 | ANALOG BOARD ASSEMBLY | 28480 | 04276-66502 |
| A2C1 | 0160-5499 | 1 | 2 | CAPACITOR- 0.22UF 100VDC F | 28480 | 0160-5499 |
| C2 | 0121-0036 | 0 | 3 | CAPACITOR-V TRMR-CER 5.5-18PF 350V | 52763 | 304324 5.5/18PF NPO |
| C3 | 0121-0036 | 0 | | CAPACITOR-V TRMR-CER 5.5-18PF 350V | 52763 | 304324 5.5/18PF NPO |
| C4 | 0160-4791 | 4 | 1 | CAPACITOR-FXD 10PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4791 |
| C5 | 0160-4788 | 9 | 1 | CAPACITOR-FXD 18PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4788 |
| C6 | 0160-3402 | 2 | 2 | CAPACITOR-FXD 1UF +-5% 50VDC MET-POLYC | 28480 | 0160-3402 |
| C7 | 0121-0105 | 4 | 3 | CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG | 52763 | 304324 9/35PF N650 |
| C8 | 0160-4835 | 7 | 3 | CAPACITOR-FXD .1UF +-10% 50VDC CER | 28480 | 0160-4835 |
| C9 | 0160-4835 | 7 | 7 | CAPACITOR-FXD .1UF +-10% 50VDC CER | 28480 | 0160-4835 |
| C10 | 0160-4835 | 7 | 7 | CAPACITOR-FXD .1UF +-10% 50VDC CER | 28480 | 0160-4835 |
| C11 | 0160-4822 | 2 | 2 | CAPACITOR-FXD 1000PF +-5% 100VDC CER | 28480 | 0160-4822 |
| C12 | 0121-0105 | 4 | 4 | CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG | 52763 | 304324 9/35PF N650 |
| C13 | 0121-0105 | 4 | 4 | CAPACITOR-V TRMR-CER 9-35PF 200V PC-MTG | 52763 | 304324 9/35PF N650 |
| C14 | 0160-2202 | 8 | 1 | CAPACITOR-FXD 75PF +-5% 300VDC MICA | 28480 | 0160-2202 |
| C15 | 0160-4789 | 0 | 1 | CAPACITOR-FXD 15PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4789 |
| C16 | 0140-0196 | 3 | 1 | CAPACITOR-FXD 150PF +-5% 300VDC MICA | 72136 | DM15F151J0300VU1CR |
| C17 | 0160-4822 | 2 | 2 | CAPACITOR-FXD 1000PF +-5% 100VDC CER | 28480 | 0160-4822 |
| C18 | 0121-0036 | 0 | 2 | CAPACITOR-V TRMR-CER 5.5-18PF 350V | 52763 | 304324 5.5/18PF NPO |
| C19 | 0160-0127 | 2 | 1 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| C20 | 0160-1674 | 6 | 1 | CAPACITOR- .33UF 5% 200VDC | 28480 | 0160-1674 |
| C21 | 0180-2951 | 6 | 24 | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C22 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C23 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C24 | 0160-4806 | 2 | 1 | CAPACITOR-FXD 39PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4806 |
| C25 | 0150-0121 | 5 | 1 | CAPACITOR-FXD .1UF +80-20% 50VDC CER | 28480 | 0150-0121 |
| C26 | 0160-5499 | 1 | | CAPACITOR- 0.22UF 100VDC F | 28480 | 0160-5499 |
| C27 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C28 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C29 | 0160-5502 | 7 | 1 | CAPACITOR- 1 UF 63 VDC F | 28480 | 0160-5502 |
| C30 | 0180-3223 | 7 | 2 | CAPACITOR-FXD 22 UF 63VDC | 28480 | 0180-3223 |
| C31 | 0180-3223 | 7 | | CAPACITOR-FXD 22 UF 63VDC | 28480 | 0180-3223 |
| C32 | 0180-3233 | 9 | 6 | CAPACITOR-FXD 22 UF 25VDCW | 28480 | 0180-3233 |
| C33 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C34 | 0180-3233 | 9 | | CAPACITOR-FXD 22 UF 25VDCW | 28480 | 0180-3233 |
| C35 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C36 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C37 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C38 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C39 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C40 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C41 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C42 | 0160-0194 | 3 | 1 | CAPACITOR-FXD .015UF +-10% 200VDC POLYE | 28480 | 0160-0194 |
| C43 | 0180-0197 | 8 | 2 | CAPACITOR-FXD 2.2UF+-10% 20VDC TA | 56289 | 150D225X9020A2 |
| C44 | 0180-0197 | 8 | | CAPACITOR-FXD 2.2UF+-10% 20VDC TA | 56289 | 150D225X9020A2 |
| C45 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C46 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C47 | 0160-4814 | 2 | 1 | CAPACITOR-FXD 150PF +-5% 100VDC CER | 28480 | 0160-4814 |
| C48 | 0160-4803 | 9 | 2 | CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4803 |
| C49 | 0160-4786 | 7 | 1 | CAPACITOR-FXD 27PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4786 |
| C50 | 0160-4792 | 5 | 1 | CAPACITOR-FXD 8.2PF +- .5PF 100VDC CER | 28480 | 0160-4792 |
| C51 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C52 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C53 | 0180-3233 | 9 | | CAPACITOR-FXD 22 UF 25VDCW | 28480 | 0180-3233 |
| C54 | 0180-3233 | 9 | | CAPACITOR-FXD 22 UF 25VDCW | 28480 | 0180-3233 |
| C55 | 0160-4803 | 9 | | CAPACITOR-FXD 68PF +-5% 100VDC CER 0+-30 | 28480 | 0160-4803 |
| C56 | 0160-1603 | 1 | 1 | C.FXD MY 1 UF 10% 100VDCW | 28480 | 0160-1603 |
| C57 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C58 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C59 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C60 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C61 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C62 | 0160-5498 | 0 | 1 | CAPACITOR- 0.01UF 50VDC F | 28480 | 0160-5498 |
| C63 | 0160-2009 | 3 | 1 | CAPACITOR-FXD 820PF +-5% 300VDC MICA | 28480 | 0160-2009 |
| C64 | 0160-3901 | 6 | 3 | CAPACITOR-FXD 2.2UF +-20% 25VDC CER | 28480 | 0160-3901 |
| C65 | 0160-3901 | 6 | | CAPACITOR-FXD 2.2UF +-20% 25VDC CER | 28480 | 0160-3901 |
| C66 | 0160-3901 | 6 | | CAPACITOR-FXD 2.2UF +-20% 25VDC CER | 28480 | 0160-3901 |
| C67 | 0180-3233 | 9 | | CAPACITOR-FXD 22 UF 25VDCW | 28480 | 0180-3233 |
| C68 | 0180-3233 | 9 | | CAPACITOR-FXD 22 UF 25VDCW | 28480 | 0180-3233 |
| C69 | 0160-5501 | 6 | 1 | CAPACITOR- 0.1 UF 100VDC F | 28480 | 0160-5501 |
| C70 | 0160-5596 | 9 | 1 | CAPACITOR- 3 PF +/- .5 PF | 28480 | 0160-5596 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|------------------|
| A2C71 | 0160-5594 | 7 | 1 | CAPACITOR- 1 PF +/- .5 PF | 28480 | 0160-5594 |
| C72 | 0160-5597 | 0 | 1 | CAPACITOR- 5 PF +/- .5 PF | 28480 | 0160-5597 |
| C73 | 0160-3402 | 2 | | CAPACITOR-FXD 1UF +-5% 50VDC MET-POLYC | 28480 | 0160-3402 |
| C74 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C75 | 0180-2951 | 6 | | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C76 | 0160-4830 | 2 | 1 | CAPACITOR-FXD 2200PF +-10% 100VDC CER | 28480 | 0160-4830 |
| A2CR1 | 1901-0376 | 6 | 5 | DIODE-GEN PRP 35V 50MA DO-35 | 28480 | 1901-0376 |
| CR2 | 1901-0033 | 2 | 7 | DIODE-GEN PRP 180V 200MA DO-7 | 28480 | 1901-0033 |
| CR3 | 1901-0033 | 2 | | DIODE-GEN PRP 180V 200MA DO-7 | 28480 | 1901-0033 |
| CR4 | 1901-0033 | 2 | | DIODE-GEN PRP 180V 200MA DO-7 | 28480 | 1901-0033 |
| CR5 | 1902-3059 | 0 | 2 | DIODE-ZNR 3.83V 5% DO-35 PD=.4W | 28480 | 1902-3059 |
| CR6 | 1902-3059 | 0 | | DIODE-ZNR 3.83V 5% DO-35 PD=.4W | 28480 | 1902-3059 |
| CR7 | 1901-0040 | 1 | 2 | DIODE-SWITCHING 30V 50MA 2NS DO-35 | 28480 | 1901-0040 |
| CR8 | 1901-0040 | 1 | | DIODE-SWITCHING 30V 50MA 2NS DO-35 | 28480 | 1901-0040 |
| CR9 | 1901-0033 | 2 | | DIODE-GEN PRP 180V 200MA DO-7 | 28480 | 1901-0033 |
| CR10 | 1901-0033 | 2 | | DIODE-GEN PRP 180V 200MA DO-7 | 28480 | 1901-0033 |
| CR11 | 1901-1065 | 2 | 4 | DIODE-PWR RECT 1N4936 400V 1A 200NS | 14936 | 1N4936 |
| CR12 | 1901-1065 | 2 | | DIODE-PWR RECT 1N4936 400V 1A 200NS | 14936 | 1N4936 |
| CR13 | 1901-1065 | 2 | | DIODE-PWR RECT 1N4936 400V 1A 200NS | 14936 | 1N4936 |
| CR14 | 1901-1065 | 2 | | DIODE-PWR RECT 1N4936 400V 1A 200NS | 14936 | 1N4936 |
| CR15 | 1901-0376 | 6 | | DIODE-GEN PRP 35V 50MA DO-35 | 28480 | 1901-0376 |
| CR16 | 1901-0376 | 6 | | DIODE-GEN PRP 35V 50MA DO-35 | 28480 | 1901-0376 |
| CR17 | 1901-0033 | 2 | | DIODE-GEN PRP 180V 200MA DO-7 | 28480 | 1901-0033 |
| CR18 | 1901-0033 | 2 | | DIODE-GEN PRP 180V 200MA DO-7 | 28480 | 1901-0033 |
| CR19 | 1901-0376 | 6 | | DIODE-GEN PRP 35V 50MA DO-35 | 28480 | 1901-0376 |
| CR20 | 1901-0376 | 6 | | DIODE-GEN PRP 35V 50MA DO-35 | 28480 | 1901-0376 |
| A2K1 | 0490-1269 | 4 | 3 | RELAY 1C 12VDC-COIL .66A 30VDC | 28480 | 0490-1269 |
| K2 | 0490-1269 | 4 | | RELAY 1C 12VDC-COIL .66A 30VDC | 28480 | 0490-1269 |
| K3 | 0490-1269 | 4 | | RELAY 1C 12VDC-COIL .66A 30VDC | 28480 | 0490-1269 |
| A2Q1 | 1855-0119 | 6 | 4 | TRANSISTOR-FET 2SK43 | 28480 | 1855-0119 |
| Q2 | 1855-0119 | 6 | | TRANSISTOR-FET 2SK43 | 28480 | 1855-0119 |
| Q3 | 1855-0119 | 6 | | TRANSISTOR-FET 2SK43 | 28480 | 1855-0119 |
| Q4 | 1854-0810 | 2 | 1 | TRANSISTOR NPN SI PD=625MW FT=200MHZ | 28480 | 1854-0810 |
| Q5 | 1853-0459 | 3 | 1 | TRANSISTOR PNP SI PD=625MW FT=200MHZ | 28480 | 1853-0459 |
| Q6 | 1855-0119 | 6 | | TRANSISTOR-FET 2SK43 | 28480 | 1855-0119 |
| A2R1 | 2100-3352 | 7 | 1 | RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3352 |
| R2 | 1810-0374 | 1 | 2 | NETWORK-RES 8-SIP1.0K OHM X 4 | 01121 | 208B102 |
| R3 | 0698-3157 | 3 | 1 | RESISTOR 19.6K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1962-F |
| R4 | 2100-2520 | 9 | 1 | RESISTOR-TRMR 50 20% C SIDE-ADJ 1-TRN | 30983 | ET50X500 |
| R5 | 2100-2583 | 4 | 4 | RESISTOR-TRMR 10 20% C SIDE-ADJ 1-TRN | 30983 | ET50X100 |
| R6 | 2100-2489 | 9 | 2 | RESISTOR-TRMR 5K 10% C SIDE-ADJ 1-TRN | 30983 | ET50X502 |
| R7 | 2100-2574 | 3 | 1 | RESISTOR-TRMR 500 10% C SIDE-ADJ 1-TRN | 30983 | ET50X501 |
| R8 | 1810-0624 | 4 | 1 | RESISTIVE NETWORK | 28480 | 1810-0624 |
| R9 | 0699-1018 | 3 | 1 | RESISTOR-100.95 OHM 0.5W | 28480 | 0699-1018 |
| R10 | 0757-0346 | 2 | 2 | RESISTOR 10 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-10R0-F |
| R11 | 0683-5605 | 9 | 3 | RESISTOR 56 5% .25W FC TC=-400/+500 | 01121 | CB5605 |
| R12 | 0683-1835 | 9 | 7 | RESISTOR 18K 5% .25W FC TC=-400/+800 | 01121 | CB1835 |
| R13 | 2100-3274 | 2 | 7 | RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3274 |
| R14 | 2100-2514 | 1 | 1 | RESISTOR-TRMR 20K 10% C SIDE-ADJ 1-TRN | 30983 | ET50W203 |
| R15 | 2100-3274 | 2 | | RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3274 |
| R16 | 2100-3274 | 2 | | RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3274 |
| R17 | 2100-3274 | 2 | | RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3274 |
| R18 | 0698-0084 | 9 | 2 | RESISTOR 2.15K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2151-F |
| R19 | 0757-0463 | 4 | 1 | RESISTOR 82.5K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-8252-F |
| R20 | 0683-1835 | 9 | | RESISTOR 18K 5% .25W FC TC=-400/+800 | 01121 | CB1835 |
| R21 | 0683-1835 | 9 | | RESISTOR 18K 5% .25W FC TC=-400/+800 | 01121 | CB1835 |
| R22 | 0683-1835 | 9 | | RESISTOR 18K 5% .25W FC TC=-400/+800 | 01121 | CB1835 |
| R23 | 1810-0621 | 1 | 2 | RESISTIVE NETWORK | 28480 | 1810-0621 |
| R24 | 0683-1835 | 9 | | RESISTOR 18K 5% .25W FC TC=-400/+800 | 01121 | CB1835 |
| R25 | 2100-3274 | 2 | | RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3274 |
| R26 | 2100-2583 | 4 | | RESISTOR-TRMR 10 20% C SIDE-ADJ 1-TRN | 30983 | ET50X100 |
| R27 | 2100-2583 | 4 | | RESISTOR-TRMR 10 20% C SIDE-ADJ 1-TRN | 30983 | ET50X100 |
| R28 | 0698-4343 | 1 | 1 | RESISTOR 100 .1% .125W F TC=0+-50 | 28480 | 0698-4343 |
| R29 | 0698-5453 | 6 | 1 | RESISTOR 900 .1% .125W F TC=0+-50 | 03888 | PM55 T-2-900R-B |
| R30 | 0757-0278 | 9 | 1 | RESISTOR 1.78K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1781-F |
| R31 | 1810-0623 | 3 | 1 | RESISTIVE NETWORK | 28480 | 1810-0623 |
| R32 | 0698-3440 | 7 | 1 | RESISTOR 196 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-196R-F |
| R33 | 0683-1835 | 9 | | RESISTOR 18K 5% .25W FC TC=-400/+800 | 01121 | CB1835 |
| R34 | 0683-1835 | 9 | | RESISTOR 18K 5% .25W FC TC=-400/+800 | 01121 | CB1835 |
| R35 | 2100-2583 | 4 | | RESISTOR-TRMR 10 20% C SIDE-ADJ 1-TRN | 30983 | ET50X100 |
| R36 | 0757-0280 | 3 | 7 | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| R37 | 0757-0416 | 7 | 2 | RESISTOR 511 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-511R-F |
| R38 | 0757-0416 | 7 | | RESISTOR 511 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-511R-F |
| R39 | 2100-3274 | 2 | | RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3274 |
| R40 | 2100-3274 | 2 | | RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3274 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|------------------|
| A2R41 | 0757-0401 | 0 | 6 | RESISTOR 100 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-101-F |
| R42 | 1810-0622 | 2 | 1 | RESISTIVE NETWORK | 28480 | 1810-0622 |
| R43 | 1810-0374 | 1 | | NETWORK-RES 8-SIP1.0K OHM X 4 | 01121 | 208B102 |
| R44 | 1810-0607 | 3 | 1 | RESISTIVE NETWORK- SIP | 28480 | 1810-0607 |
| R45 | 0698-3155 | 1 | 1 | RESISTOR 4.64K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-4641-F |
| R46 | 0683-4715 | 0 | 1 | RESISTOR 470 5% .25W FC TC=-400/+600 | 01121 | CB4715 |
| R47 | 0757-0279 | 0 | 1 | RESISTOR 3.16K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-3161-F |
| R48 | 1810-0305 | 8 | 5 | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R49 | 0683-3335 | 8 | 1 | RESISTOR 33K 5% .25W FC TC=-400/+800 | 01121 | CB3335 |
| R50 | 0757-0346 | 2 | | RESISTOR 10 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-10R0-F |
| R51 | 0757-1094 | 9 | 2 | RESISTOR 1.47K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1471-F |
| R52 | 0757-0442 | 9 | 7 | RESISTOR 10K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1002-F |
| R53 | 0757-0442 | 9 | | RESISTOR 10K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1002-F |
| R54 | 0698-3152 | 8 | 2 | RESISTOR 3.48K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-3481-F |
| R55 | 0757-0444 | 1 | 1 | RESISTOR 12.1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1212-F |
| R56 | 0757-0442 | 9 | | RESISTOR 10K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1002-F |
| R57 | 0757-1094 | 9 | | RESISTOR 1.47K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1471-F |
| R58 | 0698-0084 | 9 | | RESISTOR 2.15K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-2151-F |
| R59 | 0757-0280 | 3 | | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| R60 | 0757-0438 | 3 | 2 | RESISTOR 5.11K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-5111-F |
| R61 | 1810-0478 | 6 | 1 | NETWORK-RES 8-SIP22.0K OHM X 4 | 28480 | 1810-0478 |
| R62 | 0683-2265 | 1 | 1 | RESISTOR 22M 5% .25W FC TC=-900/+1200 | 01121 | CB2265 |
| R63 | 0698-3152 | 8 | | RESISTOR 3.48K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-3481-F |
| R64 | 0699-1022 | 9 | 1 | RESISTOR FUSE-47 OHM 1/4W | 28480 | 0699-1022 |
| R65 | 0683-1005 | 5 | 1 | RESISTOR 10 5% .25W FC TC=-400/+500 | 01121 | CB1005 |
| R66 | 0683-1025 | 9 | 1 | RESISTOR 1K 5% .25W FC TC=-400/+600 | 01121 | CB1025 |
| R67 | 0699-1020 | 7 | 1 | RESISTOR-470 OHM 1W | 28480 | 0699-1020 |
| R68 | 1810-0305 | 8 | | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R69 | 0757-0401 | 0 | | RESISTOR 100 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-101-F |
| R70 | 0757-0442 | 9 | | RESISTOR 10K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1002-F |
| R71 | 0757-0401 | 0 | | RESISTOR 100 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-101-F |
| R72 | 0757-0442 | 9 | | RESISTOR 10K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1002-F |
| R73 | 0698-0083 | 8 | 1 | RESISTOR 1.96K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1961-F |
| R74 | 0698-0083 | 8 | 1 | RESISTOR 1.96K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1961-F |
| R75 | 0698-3161 | 9 | 1 | RESISTOR 38.3K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-3832-F |
| R76 | 0757-0280 | 3 | | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| R77 | 0757-0280 | 3 | | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| R78 | 0757-0465 | 6 | 1 | RESISTOR 100K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1003-F |
| R79 | 0683-5605 | 9 | | RESISTOR 56 5% .25W FC TC=-400/+500 | 01121 | CB5605 |
| R80 | 0683-5605 | 9 | | RESISTOR 56 5% .25W FC TC=-400/+500 | 01121 | CB5605 |
| R81 | 0757-0470 | 3 | 1 | RESISTOR 162K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1623-F |
| R82 | 0698-3156 | 2 | 1 | RESISTOR 14.7K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1472-F |
| R83 | 0757-0421 | 4 | 1 | RESISTOR 825 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-825R-F |
| R84 | 0757-0399 | 5 | 1 | RESISTOR 82.5 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-82R5-F |
| R85 | 0698-3153 | 9 | 1 | RESISTOR 3.83K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-3831-F |
| R86 | 0757-0277 | 8 | 1 | RESISTOR 49.9 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-4992-F |
| R87 | 0757-0401 | 0 | | RESISTOR 100 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-101-F |
| R88 | 0757-0442 | 9 | | RESISTOR 10K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1002-F |
| R89 | 1810-0305 | 8 | | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R90 | 1810-0305 | 8 | | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R91 | 1810-0305 | 8 | | NETWORK-RES 9-SIP4.7K OHM X 8 | 28480 | 1810-0305 |
| R92 | 0757-0280 | 3 | | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| R93 | 0757-0464 | 5 | 1 | RESISTOR 90.9K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-9092-F |
| R94 | 0757-0280 | 3 | | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| R95 | 0699-1019 | 4 | 2 | RESISTOR-7.071K OHM 0.1W | 28480 | 0699-1019 |
| R96 | 0757-0438 | 3 | | RESISTOR 5.11K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-5111-F |
| R97 | 0699-1019 | 4 | | RESISTOR-7.071K OHM 0.1W | 28480 | 0699-1019 |
| R98 | 1810-0621 | 1 | | RESISTIVE NETWORK | 28480 | 1810-0621 |
| R99 | 2100-2517 | 4 | 1 | RESISTOR-TRMR 50K 10% C SIDE-ADJ 1-TRN | 30983 | ET50X503 |
| R100 | 2100-2489 | 9 | | RESISTOR-TRMR 5K 10% C SIDE-ADJ 1-TRN | 30983 | ET50X502 |
| R101 | 0757-0401 | 0 | | RESISTOR 100 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-101-F |
| R102 | 0757-0280 | 3 | | RESISTOR 1K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1001-F |
| R103 | 0757-0439 | 4 | 1 | RESISTOR 6.81K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-6811-F |
| R104 | 0757-0442 | 9 | | RESISTOR 10K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-1002-F |
| R105 | 0698-3160 | 8 | 1 | RESISTOR 31.6K 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-3162-F |
| R106 | 0757-0401 | 0 | | RESISTOR 100 1% .125W F TC=0+-100 | 24546 | C4-1/8-T0-101-F |
| R107 | 0683-3315 | 4 | 1 | RESISTOR 330 5% .25W FC TC=-400/+600 | 01121 | CB3315 |
| A2T1 | 9100-4252 | 5 | 1 | TRANSFORMER-PULSE | 28480 | 9100-4252 |
| A2U1 | 1813-0303 | 2 | 3 | IC (MISC) | 28480 | 1813-0303 |
| U2 | 1813-0303 | 2 | | IC (MISC) | 28480 | 1813-0303 |
| U3 | 1813-0303 | 2 | | IC (MISC) | 28480 | 1813-0303 |
| U4 | 1813-0298 | 4 | 2 | IC (MISC) | 28480 | 1813-0298 |
| U5 | 1826-0519 | 9 | 13 | IC OP AMP LOW-BIAS-H-IMPD 8-DIP-P PKG | 01295 | TL071CP |
| U6 | 1820-1545 | 1 | 6 | IC MULTIPLXR 2-CHAN-ANLG TRIPLE 16-DIP-C | 3L585 | CD4053BY |
| U7 | 1820-2111 | 9 | 1 | IC DRVR TTL INV | 01295 | SN75468N |
| U8 | 1820-1546 | 2 | 3 | IC MULTIPLXR 4-CHAN-ANLG DUAL 16-DIP-C | 04713 | MC14052BCL |
| U9 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMPD 8-DIP-P PKG | 01295 | TL071CP |
| U10 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMPD 8-DIP-P PKG | 01295 | TL071CP |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|------------------|
| A2 U11 | 1820-1545 | 1 | | IC MULTIPLXR 2-CHAN-ANLG TRIPLE 16-DIP-C | 3L585 | CD4053BY |
| U12 | 1820-1546 | 2 | | IC MULTIPLXR 4-CHAN-ANLG DUAL 16-DIP-C | 04713 | MC14052BCL |
| U13 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U14 | 1826-0547 | 3 | 2 | IC OP AMP LOW-BIAS-H-IMP DUAL 8-DIP-P | 01295 | TL072ACP |
| U15 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U16 | 1820-1545 | 1 | | IC MULTIPLXR 2-CHAN-ANLG TRIPLE 16-DIP-C | 3L585 | CD4053BY |
| U17 | 1820-1546 | 2 | | IC MULTIPLXR 4-CHAN-ANLG DUAL 16-DIP-C | 04713 | MC14052BCL |
| U18 | 1820-1545 | 1 | | IC MULTIPLXR 2-CHAN-ANLG TRIPLE 16-DIP-C | 3L585 | CD4053BY |
| U19 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U20 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U21 | 1820-1545 | 1 | | IC MULTIPLXR 2-CHAN-ANLG TRIPLE 16-DIP-C | 3L585 | CD4053BY |
| U22 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U23 | 1826-0175 | 3 | 1 | IC COMPARATOR GP DUAL 14-DIP-P PKG | 27014 | LM319N |
| U24 | 1820-1212 | 9 | 1 | IC FF TTL LS J-K NEG-EDGE-TRIG | 01295 | SN74LS112AN |
| U25 | 1826-0138 | 8 | 1 | IC COMPARATOR GP QUAD 14-DIP-P PKG | 01295 | LM339N |
| U26 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U27 | 1826-0248 | 1 | 1 | IC CONV 8-B-D/A 16-DIP-C PKG | 04713 | MC1408L-6 |
| U28 | 1813-0297 | 3 | 1 | IC (MISC) | 28480 | 1813-0297 |
| U29 | 1816-1533 | 8 | 1 | IC-M87051 | 28480 | 1816-1533 |
| U30 | 1820-1442 | 7 | 1 | IC CNTR TTL LS DECD ASYNCHRO | 01295 | SN74LS290N |
| U31 | 1826-0547 | 3 | | IC OP AMP LOW-BIAS-H-IMP DUAL 8-DIP-P | 01295 | TL072ACP |
| U32 | 1820-1443 | 8 | 1 | IC CNTR TTL LS BIN ASYNCHRO | 01295 | SN74LS293N |
| U33 | 1820-0683 | 6 | 1 | IC INV TTL S HEX 1-INP | 01295 | SN74S04N |
| U34 | 1820-0630 | 3 | 1 | IC MISC TTL | 04713 | MC4044P |
| U35 | 1820-1730 | 6 | 4 | IC FF TTL LS D-TYPE POS-EDGE-TRIG COM | 01295 | SN74LS273N |
| U36 | 1826-0147 | 9 | 5 | IC 7812 V RGLTR TO-220 | 04713 | MC7812CP |
| U37 | 1826-0221 | 0 | 5 | IC V RGLTR TO-220 | 04713 | MC7912CT |
| U38 | 1826-0122 | 0 | 4 | IC 7805 V RGLTR TO-220 | 07263 | 7805UC |
| U39 | 1826-0122 | 0 | | IC 7805 V RGLTR TO-220 | 07263 | 7805UC |
| U40 | 1813-0298 | 4 | | IC (MISC) | 28480 | 1813-0298 |
| U41 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U42 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U43 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U44 | 1826-0147 | 9 | | IC 7812 V RGLTR TO-220 | 04713 | MC7812CP |
| U45 | 1826-0221 | 0 | | IC V RGLTR TO-220 | 04713 | MC7912CT |
| U46 | 1826-0221 | 0 | | IC V RGLTR TO-220 | 04713 | MC7912CT |
| U47 | 1826-0147 | 9 | | IC 7812 V RGLTR TO-220 | 04713 | MC7812CP |
| U48 | 1820-1545 | 1 | | IC MULTIPLXR 2-CHAN-ANLG TRIPLE 16-DIP-C | 3L585 | CD4053BY |
| U49 | 1826-0519 | 9 | | IC OP AMP LOW-BIAS-H-IMP 8-DIP-P PKG | 01295 | TL071CP |
| U50 | 1820-1730 | 6 | | IC FF TTL LS D-TYPE POS-EDGE-TRIG COM | 01295 | SN74LS273N |
| U51 | 1820-1730 | 6 | | IC FF TTL LS D-TYPE POS-EDGE-TRIG COM | 01295 | SN74LS273N |
| U52 | 1820-1730 | 6 | | IC FF TTL LS D-TYPE POS-EDGE-TRIG COM | 01295 | SN74LS273N |
| U53 | 1826-0147 | 9 | | IC 7812 V RGLTR TO-220 | 04713 | MC7812CP |
| U54 | 1826-0221 | 0 | | IC V RGLTR TO-220 | 04713 | MC7912CT |
| U55 | 1826-0122 | 0 | | IC 7805 V RGLTR TO-220 | 07263 | 7805UC |
| U56 | 1826-0122 | 0 | | IC 7805 V RGLTR TO-220 | 07263 | 7805UC |
| U57 | 1820-1416 | 5 | 1 | IC SCHMITT-TRIG TTL LS INV HEX 1-INP | 01295 | SN74LS14N |
| U58 | 1826-0522 | 4 | 1 | IC OP AMP LOW-BIAS-H-IMP QUAD 14-DIP-P | 01295 | TL074CN |
| U59 | 1813-0296 | 2 | 3 | IC (MISC) | 28480 | 1813-0296 |
| U60 | 1813-0296 | 2 | | IC (MISC) | 28480 | 1813-0296 |
| U61 | 1813-0296 | 2 | | IC (MISC) | 28480 | 1813-0296 |
| U62 | 1820-1975 | 1 | 3 | IC SHF-RGTR TTL LS NEG-EDGE-TRIG PRL-IN | 01295 | SN74LS165N |
| U63 | 1820-1975 | 1 | | IC SHF-RGTR TTL LS NEG-EDGE-TRIG PRL-IN | 01295 | SN74LS165N |
| U64 | 1820-1975 | 1 | | IC SHF-RGTR TTL LS NEG-EDGE-TRIG PRL-IN | 01295 | SN74LS165N |
| U65 | 1813-0302 | 1 | 1 | IC (MISC) | 28480 | 1813-0302 |
| U66 | 1826-0221 | 0 | | IC V RGLTR TO-220 | 04713 | MC7912CT |
| U67 | 1826-0147 | 9 | | IC 7812 V RGLTR TO-220 | 04713 | MC7812CP |
| U68 | 1820-0475 | 4 | 1 | IC COMPARATOR HS TO-99 PKG | 27014 | LM306H |
| A2 W1 | 8159-0005 | 0 | 10 | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W2 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W3 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W4 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W5 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W6 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W7 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W8 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W9 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| W10 | 8159-0005 | 0 | | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| | | | | MISCELLANEDUS PARTS | | |
| | 0340-0060 | 4 | 4 | TERMINAL-STUD SPCL-FDTHRU PRESS-MTG | 98291 | 011-6809 000 209 |
| | 0340-0092 | 2 | 7 | TERMINAL-STUD SPCL-FDTHRU PRESS-MTG | 28480 | 0340-0092 |
| | 0340-0220 | 8 | 28 | | 28480 | 0340-0220 |
| | 0340-1049 | 1 | 14 | SPACER-TO220 | 28480 | 0340-1049 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|---|----------|-----------------|
| A 4 | | | | | | |
| | 04276-66504 | 3 | 1 | POWER SUPPLY BOARD ASSEMBLY | 28480 | 04276-66504 |
| A4C1 | 0180-1075 | 3 | 3 | CAPACITOR-FXD 2200 UF 16VDC AL | 28480 | 0180-1075 |
| C2 | 0180-2980 | 1 | 2 | CAPACITOR-FXD 1000UF+-20% 35VDC AL | 28480 | 0180-2980 |
| C3 | 0180-2980 | 1 | | CAPACITOR-FXD 1000UF+-20% 35VDC AL | 28480 | 0180-2980 |
| C4 | 0180-1075 | 3 | | CAPACITOR-FXD 2200 UF 16VDC AL | 28480 | 0180-1075 |
| C5 | 0180-3221 | 5 | 6 | CAPACITOR-FXD 10 UF 100VDC | 28480 | 0180-3221 |
| C6 | 0180-3221 | 5 | | CAPACITOR-FXD 10 UF 100VDC | 28480 | 0180-3221 |
| C7 | 0180-3221 | 5 | | CAPACITOR-FXD 10 UF 100VDC | 28480 | 0180-3221 |
| C8 | 0180-3221 | 5 | | CAPACITOR-FXD 10 UF 100VDC | 28480 | 0180-3221 |
| C9 | 0180-3221 | 5 | | CAPACITOR-FXD 10 UF 100VDC | 28480 | 0180-3221 |
| C10 | 0180-3221 | 5 | | CAPACITOR-FXD 10 UF 100VDC | 28480 | 0180-3221 |
| C11 | 0180-1050 | 4 | 3 | CAPACITOR-FXD 100UF 25VDC | 28480 | 0180-1050 |
| C12 | 0180-1050 | 4 | | CAPACITOR-FXD 100UF 25VDC | 28480 | 0180-1050 |
| C13 | 0180-1050 | 4 | | CAPACITOR-FXD 100UF 25VDC | 28480 | 0180-1050 |
| C14 | 0160-2055 | 9 | 1 | CAPACITOR-FXD .01UF +80-20% 100VDC CER | 28480 | 0160-2055 |
| C15 | 0180-1075 | 3 | | CAPACITOR-FXD 2200 UF 16VDC AL | 28480 | 0180-1075 |
| C16 | 0160-3456 | 6 | 1 | CAPACITOR-FXD 1000PF +-10% 1KVDC CER | 28480 | 0160-3456 |
| C17 | 0180-0197 | 8 | 1 | CAPACITOR-FXD 2.2UF+-10% 20VDC TA | 56289 | 150D225X9020A2 |
| C18 | 0160-4822 | 2 | 1 | CAPACITOR-FXD 1000PF +-5% 100VDC CER | 28480 | 0160-4822 |
| C19 | 0180-0291 | 3 | 1 | CAPACITOR-FXD 1UF+-10% 35VDC TA | 56289 | 150D105X9035A2 |
| C20 | 0160-3094 | 8 | 1 | CAPACITOR-FXD .1UF +-10% 100VDC CER | 28480 | 0160-3094 |
| C21 | 0180-1704 | 5 | 1 | CAPACITOR-FXD 47UF+-10% 6VDC TA | 56289 | 150D476X9006B2 |
| C22 | 0180-0228 | 6 | 2 | CAPACITOR-FXD 22UF+-10% 15VDC TA | 56289 | 150D226X9015B2 |
| C23 | 0160-0127 | 2 | 3 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| C24 | 0160-0127 | 2 | | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| C25 | 0160-4593 | 4 | 2 | CAPACITOR-FXD 1.5UF +-20% 400VDC | 28480 | 0160-4593 |
| C26 | 0160-0127 | 2 | | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| C27 | 0180-1746 | 5 | 1 | CAPACITOR-FXD 15UF+-10% 20VDC TA | 56289 | 150D156X9020B2 |
| C28 | 0160-4593 | 4 | | CAPACITOR-FXD 1.5UF +-20% 400VDC | 28480 | 0160-4593 |
| C29 | 0180-3231 | 7 | 4 | CAPACITOR-FXD 4.7 UF 450VDC | 28480 | 0180-3231 |
| C30 | 0180-3231 | 7 | | CAPACITOR-FXD 4.7 UF 450VDC | 28480 | 0180-3231 |
| C31 | 0180-3231 | 7 | | CAPACITOR-FXD 4.7 UF 450VDC | 28480 | 0180-3231 |
| C32 | 0180-3231 | 7 | | CAPACITOR-FXD 4.7 UF 450VDC | 28480 | 0180-3231 |
| C33 | 0180-3253 | 6 | 2 | CAPACITOR-FXD 470 UF 200VDC | 28480 | 0180-3253 |
| C34 | 0180-3253 | 6 | | CAPACITOR-FXD 470 UF 200VDC | 28480 | 0180-3253 |
| C35 | 0160-3969 | 6 | 2 | CAPACITOR-FXD .015UF +-20PF 250VAC(RMS) | 28480 | 0160-3969 |
| C36 | 0160-3969 | 6 | | CAPACITOR-FXD .015UF +-20PF 250VAC(RMS) | 28480 | 0160-3969 |
| C37 | 0180-0228 | 6 | | CAPACITOR-FXD 22UF+-10% 15VDC TA | 56289 | 150D226X9015B2 |
| A4CR1 | 1902-1217 | 8 | 1 | DIODE-ZNR 6.2V 5% DO-4 PD=10W TC=+.035% | 28480 | 1902-1217 |
| CR2 | 1902-3234 | 3 | 2 | DIODE-ZNR 19.6V 5% DO-35 PD=.4W | 28480 | 1902-3234 |
| CR3 | 1902-3234 | 3 | | DIODE-ZNR 19.6V 5% DO-35 PD=.4W | 28480 | 1902-3234 |
| CR4 | 1901-0025 | 2 | 11 | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR5 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR6 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR7 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR8 | 1901-0691 | 8 | 6 | DIODE-PWR RECT 100V 3A 200NS | 03508 | A115A |
| CR9 | 1901-0691 | 8 | | DIODE-PWR RECT 100V 3A 200NS | 03508 | A115A |
| CR10 | 1901-0691 | 8 | | DIODE-PWR RECT 100V 3A 200NS | 03508 | A115A |
| CR11 | 1901-0691 | 8 | | DIODE-PWR RECT 100V 3A 200NS | 03508 | A115A |
| CR12 | 1901-0691 | 8 | | DIODE-PWR RECT 100V 3A 200NS | 03508 | A115A |
| CR13 | 1901-0691 | 8 | | DIODE-PWR RECT 100V 3A 200NS | 03508 | A115A |
| CR14 | 1901-0969 | 3 | 2 | DIODE-POWER RECT. | 28480 | 1901-0969 |
| CR15 | 1901-0969 | 3 | | DIODE-POWER RECT. | 28480 | 1901-0969 |
| CR16 | 1902-3182 | 0 | 1 | DIODE-ZNR 12.1V 5% DO-35 PD=.4W | 28480 | 1902-3182 |
| CR17 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR18 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR19 | 1902-3203 | 6 | 1 | DIODE-ZNR 14.7V 5% DO-35 PD=.4W | 28480 | 1902-3203 |
| CR20 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR21 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR22 | 1902-0555 | 5 | 1 | DIODE-ZNR 13V 5% PD=1W IR=5UA | 28480 | 1902-0555 |
| CR23 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR24 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR25 | 1901-1065 | 2 | 3 | DIODE-PWR RECT 1N4936 400V 1A 200NS | 14936 | 1N4936 |
| CR26 | 1901-1065 | 2 | | DIODE-PWR RECT 1N4936 400V 1A 200NS | 14936 | 1N4936 |
| CR27 | 1901-1065 | 2 | | DIODE-PWR RECT 1N4936 400V 1A 200NS | 14936 | 1N4936 |
| CR28 | 1902-3191 | 1 | 1 | DIODE-ZNR 13V 2% DO-35 PD=.4W TC=+.06% | 28480 | 1902-3191 |
| CR29 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR30 | 1906-0080 | 9 | 1 | DIODE-FW BRDG 600V 10A | 28480 | 1906-0080 |
| A4F1 | 2110-0004 | 1 | 1 | FUSE .25A 250V NTD 1.25X.25 UL | 28480 | 2110-0004 |
| F2 | 2110-0305 | 5 | 1 | FUSE 1.25A 250V TD 1.25X.25 UL | 75915 | 3131.25 |
| F3 | 2110-0007 | 4 | 1 | FUSE 1A 250V TD 1.25X.25 UL | 75915 | 3130.01 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|-------------------|
| A4J1 | 1251-4938 | 5 | 1 | CONNECTOR 3-PIN M METRIC POST TYPE | 28480 | 1251-4938 |
| J2 | 1251-3837 | 1 | 1 | CONNECTOR 4-PIN M UTILITY | 28480 | 1251-3837 |
| A4L1 | 9100-3139 | 5 | 1 | INDUCTOR 75UH 15% .5DX.875LG | 28480 | 9100-3139 |
| L2 | 9140-0758 | 3 | 1 | INDUCTOR- 787 UH | 28480 | 9140-0758 |
| L3 | 9140-0171 | 3 | 4 | INDUCTOR RF-CH-MLD 40UH 10% .296DX.968LG | 28480 | 9140-0171 |
| L4 | 9140-0171 | 3 | 3 | INDUCTOR RF-CH-MLD 40UH 10% .296DX.968LG | 28480 | 9140-0171 |
| L5 | 9140-0462 | 5 | 1 | INDUCTOR 355UH | 28480 | 9140-0462 |
| L6 | 9140-0757 | 0 | 1 | INDUCTOR- 980 UH | 28480 | 9140-0757 |
| L7 | 9140-0171 | 3 | 1 | INDUCTOR RF-CH-MLD 40UH 10% .296DX.968LG | 28480 | 9140-0171 |
| L8 | 9140-0463 | 6 | 1 | INDUCTOR 18MH 6% INDUCTOR RF-CH-MLD 40UH 10% .296DX.968LG | 28480 | 9140-0463 |
| L9 | 9140-0171 | 3 | 1 | INDUCTOR RF-CH-MLD 40UH 10% .296DX.968LG | 28480 | 9140-0171 |
| L10 | 9140-0210 | 1 | 1 | INDUCTOR RF-CH-MLD 100UH 5% .166DX.385LG | 28480 | 9140-0210 |
| A4Q1 | 1853-0281 | 9 | 3 | TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW | 94713 | 2N2907A |
| Q2 | 1854-0477 | 7 | 5 | TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW | 04713 | 2N2222A |
| Q3 | 1854-0477 | 7 | 7 | TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW | 04713 | 2N2222A |
| Q4 | 1854-0477 | 7 | 7 | TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW | 04713 | 2N2222A |
| Q5 | 1853-0281 | 9 | 9 | TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW | 04713 | 2N2907A |
| Q6 | 1854-0477 | 7 | 7 | TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW | 04713 | 2N2222A |
| Q7 | 1853-0281 | 9 | 9 | TRANSISTOR PNP 2N2907A SI TO-18 PD=400MW | 04713 | 2N2907A |
| Q8 | 1854-0624 | 6 | 2 | TRANSISTOR NPN 2N6308 SI TO-3 PD=125W | 04713 | 2N6308 |
| Q9 | 1854-0624 | 6 | 6 | TRANSISTOR NPN 2N6308 SI TO-3 PD=125W | 04713 | 2N6308 |
| Q10 | 1854-0935 | 2 | 1 | TRANSISTOR-NPN | 28480 | 1854-0935 |
| Q11 | 1854-0936 | 3 | 1 | TRANSISTOR-NPN | 28480 | 1854-0936 |
| Q12 | 1854-0477 | 7 | 7 | TRANSISTOR NPN 2N2222A SI TO-18 PD=500MW | 04713 | 2N2222A |
| A4R1 | 0683-2235 | 5 | 1 | RESISTOR 22K 5% .25W FC TC=-400/+800 | 01121 | CB2235 |
| R2 | 0683-4705 | 8 | 3 | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| R3 | 0683-1005 | 5 | 3 | RESISTOR 10 5% .25W FC TC=-400/+500 | 01121 | CB1005 |
| R4 | 0683-1515 | 2 | 1 | RESISTOR 150 5% .25W FC TC=-400/+600 | 01121 | CB1515 |
| R5 | 0683-4715 | 0 | 3 | RESISTOR 470 5% .25W FC TC=-400/+600 | 01121 | CB4715 |
| R6 | 0683-4715 | 0 | 3 | RESISTOR 470 5% .25W FC TC=-400/+600 | 01121 | CB4715 |
| R7 | 0683-4735 | 4 | 2 | RESISTOR 47K 5% .25W FC TC=-400/+800 | 01121 | CB4735 |
| R8 | 0683-4735 | 4 | 4 | RESISTOR 47K 5% .25W FC TC=-400/+800 | 01121 | CB4735 |
| R9 | 0683-4715 | 0 | 2 | RESISTOR 470 5% .25W FC TC=-400/+600 | 01121 | CB4715 |
| R10 | 0683-1525 | 4 | 2 | RESISTOR 1.5K 5% .25W FC TC=-400/+700 | 01121 | CB1525 |
| R11 | 0683-1525 | 4 | 4 | RESISTOR 1.5K 5% .25W FC TC=-400/+700 | 01121 | CB1525 |
| R12 | 0683-4705 | 8 | 1 | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| R13 | 0683-4705 | 8 | 1 | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| R14 | 2100-3352 | 7 | 1 | RESISTOR-TRMR 1K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3352 |
| R15 | 2100-3274 | 2 | 1 | RESISTOR-TRMR 10K 10% C SIDE-ADJ 1-TRN | 28480 | 2100-3274 |
| R16 | 0683-1025 | 9 | 1 | RESISTOR 1K 5% .25W FC TC=-400/+600 | 01121 | CB1025 |
| R17 | 0764-0015 | 7 | 1 | RESISTOR 560 5% 2W MO TC=0+-200 | 28480 | 0764-0015 |
| R18 | 0683-0335 | 2 | 2 | RESISTOR 3.3 5% .25W FC TC=-400/+500 | 01121 | CB3305 |
| R19 | 0683-1005 | 5 | 1 | RESISTOR 10 5% .25W FC TC=-400/+500 | 01121 | CB1005 |
| R20 | 0683-0335 | 2 | 1 | RESISTOR 3.3 5% .25W FC TC=-400/+500 | 01121 | CB3305 |
| R21 | 0683-1005 | 5 | 1 | RESISTOR 10 5% .25W FC TC=-400/+500 | 01121 | CB1005 |
| R22 | 0683-5615 | 1 | 1 | RESISTOR 560 5% .25W FC TC=-400/+600 | 01121 | CB5615 |
| R23 | 0683-1035 | 1 | 1 | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| R24 | 0683-0275 | 9 | 4 | RESISTOR 2.7 5% .25W FC TC=-400/+500 | 01121 | CB2705 |
| R25 | 0683-0275 | 9 | 4 | RESISTOR 2.7 5% .25W FC TC=-400/+500 | 01121 | CB2705 |
| R26 | 0683-0275 | 9 | 1 | RESISTOR 2.7 5% .25W FC TC=-400/+500 | 01121 | CB2705 |
| R27 | 0683-0275 | 9 | 1 | RESISTOR 2.7 5% .25W FC TC=-400/+500 | 01121 | CB2705 |
| R28 | 0766-0033 | 3 | 1 | RESISTOR 2K 2% 3W MO TC=0+-250 | 27167 | FP3-3-250-2001-G |
| R29 | 0761-0004 | 8 | 1 | RESISTOR 20K 5% 1W MO TC=0+-200 | 28480 | 0761-0004 |
| R30 | 0699-1057 | 4 | 1 | RESISTOR 15 10% 3W | 28480 | 0699-1057 |
| R31 | 0686-3945 | 2 | 1 | RESISTOR 390K 5% .5W CC TC=0+882 | 01121 | EB3945 |
| R32 | 0683-5635 | 5 | 1 | RESISTOR 56K 5% .25W FC TC=-400/+800 | 01121 | CB5635 |
| R33 | 0686-1055 | 1 | 1 | RESISTOR 1M 5% .5W CC TC=0+1000 | 01121 | EB1055 |
| R34 | 0698-3657 | 8 | 2 | RESISTOR 68K 5% 2W MO TC=0+-200 | 27167 | FP42-2-T00-6802-J |
| R35 | 0698-3657 | 8 | 2 | RESISTOR 68K 5% 2W MO TC=0+-200 | 27167 | FP42-2-T00-6802-J |
| R36 | 0811-1670 | 3 | 1 | RESISTOR 2.2 5% 2W PW TC=0+-400 | 75042 | 8WH2-2R2-J |
| A4RT1 | 0839-0006 | 5 | 1 | THERMISTOR DISC | 28480 | 0839-0006 |
| A4RV1 | 0837-0237 | 0 | 1 | VARIATOR | 28480 | 0837-0237 |
| RV2 | 0837-0106 | 2 | 1 | VARIATOR | 28480 | 0837-0106 |
| A4T1 | 9100-4287 | 1 | 1 | TRANSFORMER-POWER | 28480 | 9100-4287 |
| T2 | 9100-0857 | 8 | 1 | TRANSFORMER-PULSE 114H1 | 28480 | 9100-0857 |
| T3 | 9100-4293 | 2 | 1 | TRANSFORMER-PULSE | 28480 | 9100-4293 |
| A4U1 | 1813-0255 | 3 | 1 | IC-REGULATOR HYBRID | 28480 | 1813-0255 |
| A4W1 | 8159-0005 | 0 | 1 | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| | | | | MISCELLANEOUS PARTS | | |
| | 0340-0060 | 4 | 1 | TERMINAL-STUD SPCL-FDTHRU PRESS-MTG | 98291 | 011-6809 000 209 |
| | 0340-0092 | 2 | 1 | TERMINAL-STUD SPCL-FDTHRU PRESS-MTG | 28480 | 0340-0092 |
| | 0340-0220 | 8 | 5 | TERMINAL-STUD SPCL-FDTHRU PRESS-MTG | 28480 | 0340-0220 |
| | 0380-0465 | 7 | 3 | SPACER-RND .188-IN-LG .194-IN-ID | 28480 | 0380-0465 |
| | 2110-0269 | 0 | 6 | FUSEHOLDER-CLIP TYPE.250-FUSE | 28480 | 2110-0269 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|--------|-----|--|----------|----------------------|
| | 2360-0115 | 4 | 6 | SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI | 00000 | ORDER BY DESCRIPTION |
| | 2740-0003 | 5 | 1 | NUT-HEX-W/LKWR 10-32-THD .125-IN-THK | 00000 | ORDER BY DESCRIPTION |
| | 04276-01204 | 4 | 1 | ANGLE (HEATSINK) | 28480 | 04276-01204 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|-----------------|
| A5 | | | | | | |
| | 04276-66505 | 4 | 1 | DISPLAY BOARD ASSEMBLY | 28480 | 04276-66505 |
| A5C1 | 0180-1085 | 5 | 4 | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C2 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C3 | 0180-3218 | 0 | 1 | CAPACITOR-FXD 1 UF 63VDC AL | 28480 | 0180-3218 |
| C4 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| C5 | 0180-1085 | 5 | | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| A5DS1 | 1990-0540 | 3 | 10 | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS2 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS3 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS4 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS5 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS6 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS7 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS8 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS9 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS10 | 1990-0540 | 3 | | DISPLAY-NUM-SEG 1-CHAR .43-H | 28480 | 5082-7650 |
| DS11 | 1990-0531 | 2 | 4 | DISPLAY-NUM-SEG 1-CHAR .3-H | 28480 | 5082-7610 |
| DS12 | 1990-0531 | 2 | | DISPLAY-NUM-SEG 1-CHAR .3-H | 28480 | 5082-7610 |
| DS13 | 1990-0531 | 2 | | DISPLAY-NUM-SEG 1-CHAR .3-H | 28480 | 5082-7610 |
| DS14 | 1990-0531 | 2 | | DISPLAY-NUM-SEG 1-CHAR .3-H | 28480 | 5082-7610 |
| DS15 | 1990-0486 | 6 | 51 | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS16 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS17 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS18 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS19 | 1990-0665 | 3 | 5 | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 1990-0665 |
| DS20 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS21 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS22 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS23 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS24 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS25 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS26 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS27 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS28 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS29 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS30 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS31 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS32 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS33 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS34 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS35 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS36 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS37 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS38 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS39 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS40 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS41 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS42 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS43 | 1990-0665 | 3 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 1990-0665 |
| DS44 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS45 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS46 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS47 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS48 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS49 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS50 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS51 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS52 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS53 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS54 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS55 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS56 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS57 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS58 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS59 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS60 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS61 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS62 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS63 | 1990-0665 | 3 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 1990-0665 |
| DS64 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |
| DS65 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX BVR=5V | 28480 | 5082-4684 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|-----------------|
| A5DS66 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX SVR=5V | 28480 | 5082-4684 |
| DS67 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX SVR=5V | 28480 | 5082-4684 |
| DS68 | 1990-0486 | 6 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX SVR=5V | 28480 | 5082-4684 |
| DS69 | 1990-0665 | 3 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX SVR=5V | 28480 | 1990-0665 |
| DS70 | 1990-0665 | 3 | | LED-LAMP LUM-INT=1MCD IF=20MA-MAX SVR=5V | 28480 | 1990-0665 |
| A5J1 THRU J14 | 1200-0630 | 7 | 14 | SOCKET-IC 14-CONT DIP DIP-SLDR | 28480 | 1200-0630 |
| A5R1 | 1810-0301 | 4 | 2 | NETWORK-RES 16-DIP51.0 OHM X B | 01121 | 3168510 |
| R2 | 1810-0627 | 7 | 3 | RESISTIVE NETWORK | 28480 | 1810-0627 |
| R3 | 1810-0301 | 4 | | NETWORK-RES 16-DIP51.0 OHM X B | 01121 | 3168510 |
| R4 | 1810-0627 | 7 | | RESISTIVE NETWORK | 28480 | 1810-0627 |
| R5 | 1810-0627 | 7 | | RESISTIVE NETWORK | 28480 | 1810-0627 |
| R7 | 0683-4725 | 2 | 1 | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| A5S1 | 5060-9436 | 7 | 17 | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S2 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S3 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S4 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S5 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S6 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S7 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S8 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S9 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S11 | 3101-1074 | 9 | 2 | SWITCH-PUSHBUTTON SPST NO | 28480 | 3101-1074 |
| S12 | 3101-1074 | 9 | | SWITCH-PUSHBUTTON SPST NO | 28480 | 3101-1074 |
| S13 | 3101-2046 | 7 | 1 | SWITCH-SLIDE DPDT-NS | 28480 | 3101-2046 |
| S14 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S15 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S16 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S17 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S18 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S19 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S20 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| S21 | 5060-9436 | 7 | | PUSHBUTTON SWITCH P.C. MOUNT | 28480 | 5060-9436 |
| A5U1 | 1858-0038 | 4 | 4 | TRANSISTOR ARRAY | 28480 | 1858-0038 |
| U2 | 1820-0495 | 8 | 1 | IC DCDR TTL 4-TO-16-LINE 4-INP | 01295 | SN74154N |
| U3 | 1820-1624 | 7 | 2 | IC BFR TTL S OCTL 1-INP | 01295 | SN74S241N |
| U4 | 1820-1624 | 7 | | IC BFR TTL S OCTL 1-INP | 01295 | SN74S241N |
| U5 | 1858-0038 | 4 | | TRANSISTOR ARRAY | 28480 | 1858-0038 |
| U6 | 1858-0038 | 4 | | TRANSISTOR ARRAY | 28480 | 1858-0038 |
| U7 | 1858-0038 | 4 | | TRANSISTOR ARRAY | 28480 | 1858-0038 |
| U8 | 1820-1216 | 3 | 1 | IC DCDR TTL LS 3-TO-8-LINE 3-INP | 01295 | SN74LS138N |
| U9 | 1816-1533 | 8 | 1 | IC-MB7051 | 28480 | 1816-1533 |
| MISCELLANEOUS PARTS | | | | | | |
| | 0360-1901 | 6 | 1 | CABLE TRANSISTION | 28480 | 0360-1901 |
| | 5041-0309 | 5 | 3 | KEY CAP | 28480 | 5041-0309 |
| | 5041-0318 | 6 | 3 | KEY CAP | 28480 | 5041-0318 |
| | 5041-0375 | 5 | 1 | KEY CAP-QUARTER(SMOKE) | 28480 | 5041-0375 |
| | 5041-0384 | 6 | 2 | KEY CAP-QUARTER(SMOKE) | 28480 | 5041-0384 |
| | 5041-0922 | 8 | 8 | KEY CAP-QUARTER(ERY PEARL) | 28480 | 5041-0922 |
| | 04191-40002 | 0 | 1 | INSULATOR | 28480 | 04191-40002 |
| | 04262-40001 | 5 | 6 | INSULATOR | 28480 | 04262-40001 |
| | 04274-40003 | 1 | 3 | INSULATOR | 28480 | 04274-40003 |
| | 04276-61641 | 9 | 1 | CABLE ASSEMBLY-FLAT | 28480 | 04276-61641 |
| | 5040-3323 | | 1 | INSULATOR | | |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|--------|-----|--------------------------------------|----------|-----------------|
| A 6 | | | | | | |
| | 04276-66506 | 5 | 1 | MOTHER BOARD ASSEMBLY | 28480 | 04276-66506 |
| A6BT1 | 1420-0306 | 2 | 1 | BATTERY- 2.4V | 28480 | 1420-0306 |
| A6J1 | 1251-7845 | 9 | 1 | CONNECTOR- 6 PIN, MALE | 28480 | 1251-7845 |
| J2 | 1251-5382 | 5 | 1 | CONNECTOR 4-PIN M METRIC POST TYPE | 28480 | 1251-5382 |
| J4 | 1251-0541 | 8 | 1 | CONNECTOR 34-PIN M RECTANGULAR | 28480 | 1251-0541 |
| A6U1 | 1813-0304 | 3 | 1 | IC (MISC) SIP | 28480 | 1813-0304 |
| A6XA1L | 1251-2582 | 1 | 5 | CONNECTOR-PC EDGE 24-CONT/ROW 2-ROWS | 28480 | 1251-2582 |
| XA1R | 1251-2582 | 1 | | CONNECTOR-PC EDGE 24-CONT/ROW 2-ROWS | 28480 | 1251-2582 |
| XA2C | 1251-2026 | 8 | 2 | CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS | 28480 | 1251-2026 |
| XA2L | 1251-2582 | 1 | | CONNECTOR-PC EDGE 24-CONT/ROW 2-ROWS | 28480 | 1251-2582 |
| XA2R | 1251-2582 | 1 | | CONNECTOR-PC EDGE 24-CONT/ROW 2-ROWS | 28480 | 1251-2582 |
| XA4C | 1251-2026 | 8 | | CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS | 28480 | 1251-2026 |
| XA4R | 1251-2582 | 1 | | CONNECTOR-PC EDGE 24-CONT/ROW 2-ROWS | 28480 | 1251-2582 |
| XA21 | 1251-4978 | 3 | 3 | CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS | 05574 | 000231-3944 |
| XA22 | 1251-4978 | 3 | | CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS | 05574 | 000231-3944 |
| XA23 | 1251-4978 | 3 | | CONNECTOR-PC EDGE 18-CONT/ROW 2-ROWS | 05574 | 000231-3944 |
| | | | | MISCELLANEOUS PARTS | | |
| | 0360-1244 | 0 | 4 | TERMINAL-SPECIAL-FEEDTHRU | 28480 | 0360-1244 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

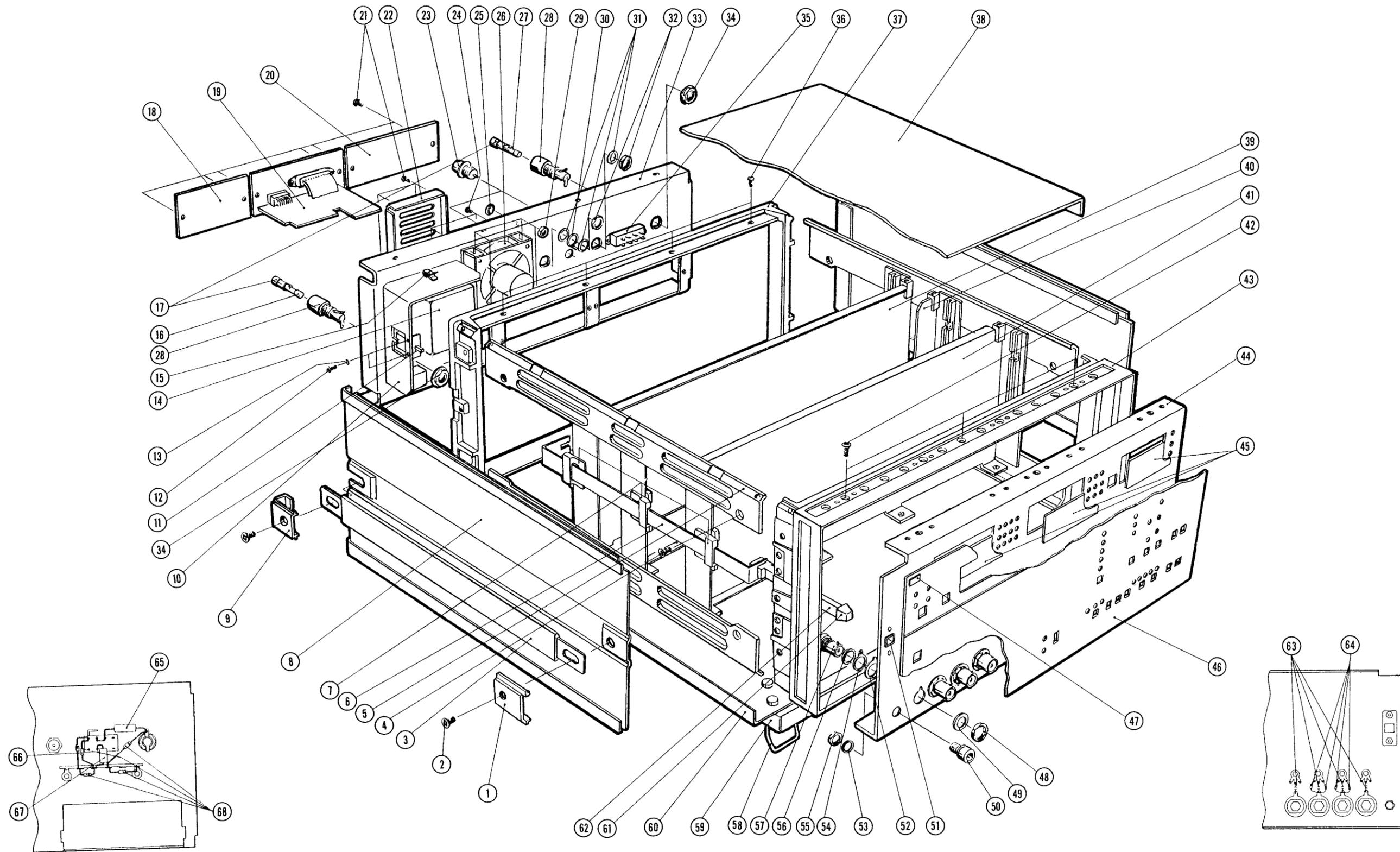
| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|---|----------|----------------------|
| A 2 1 | | | | | | |
| | 04276-66521 | 4 | 1 | HP-IB BOARD ASSEMBLY | 28480 | 04276-66521 |
| A21 C1 | 0180-2981 | 2 | 1 | CAPACITOR-FXD 220UF+-20% 10VDC AL | 28480 | 0180-2981 |
| C2 | 0180-1085 | 5 | 1 | CAPACITOR-FXD 4.7UF 16VDC TA | 28480 | 0180-1085 |
| A21 J1 | 1200-0485 | 2 | 1 | SOCKET-IC 14-CONT DIP DIP-SLDR | 28480 | 1200-0485 |
| J2 | 1200-0654 | 7 | 1 | SOCKET-IC 40-CONT DIP DIP-SLDR | 28480 | 1200-0654 |
| A21 R1 | 0683-4725 | 2 | 3 | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CR4725 |
| R2 | 0683-4725 | 2 | 3 | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CR4725 |
| R3 | 0683-4725 | 2 | 3 | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CR4725 |
| R4 | 0683-4725 | 2 | 3 | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CR4725 |
| A21 S1 | 3101-1973 | 7 | 1 | SWITCH-SL 7-1A DIP-SLIDE-ASSY .1A 50VDC | 28480 | 3101-1973 |
| A21 U1 | 1820-2024 | 3 | 1 | IC DRVR TTL LS LINE DRVR OCTL | 01295 | SN74LS244N |
| U2 | 1820-2058 | 3 | 4 | IC MISC TTL S QUAD | 07263 | MC3448AL |
| U3 | 1820-2058 | 3 | 4 | IC MISC TTL S QUAD | 07263 | MC3448AL |
| U4 | 1820-2549 | 7 | 1 | IC-8291A P HPTR | 28480 | 1820-2549 |
| U5 | 1820-1199 | 1 | 1 | IC INV TTL LS HEX 1-INP | 01295 | SN74LS04N |
| U6 | 1820-2058 | 3 | 4 | IC MISC TTL S QUAD | 07263 | MC3448AL |
| U7 | 1820-2058 | 3 | 4 | IC MISC TTL S QUAD | 07263 | MC3448AL |
| U8 | 1820-2075 | 4 | 1 | IC MISC TTL LS | 01295 | SN74LS245N |
| A21 W1 | 8159-0005 | 0 | 1 | RESISTOR-ZERO OHMS 22 AWG LEAD DIA | 28480 | 8159-0005 |
| MISCELLANEDUS PARTS | | | | | | |
| | 2360-0113 | 2 | 2 | SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI | 00000 | ORDER BY DESCRIPTION |
| | 04276-00604 | 6 | 1 | PLATE (HP-IB) | 28480 | 04276-00604 |
| | 04276-61661 | 3 | 1 | CABLE ASSEMBLY | 28480 | 04276-61661 |
| A 2 2 | | | | | | |
| | 04276-66522 | 5 | 1 | OPTION 001 INTERNAL DC BIAS BOARD ASSEMBLY | 28480 | 04276-66522 |
| A22 C1 | 0180-2951 | 6 | 4 | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C2 | 0160-5498 | 9 | 1 | CAPACITOR-FXD .01UF +80-20% 100VDC CER | 28480 | 0180-2951 |
| C3 | 0180-2951 | 6 | 4 | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C4 | 0180-2951 | 6 | 4 | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C5 | 0180-2951 | 6 | 4 | CAPACITOR-FXD 33UF+-20% 16VDC AL | 28480 | 0180-2951 |
| C6 | 0180-3220 | 4 | 2 | CAPACITOR-FXD 10 UF 63VDC AL | 28480 | 0180-3220 |
| C7 | 0180-3220 | 4 | 2 | CAPACITOR-FXD 10 UF 63VDC AL | 28480 | 0180-3220 |
| C8 | 0150-5599 | 5 | 1 | CAPACITOR-FXD .1UF +80-20% 50VDC CER | 28480 | 0180-3220 |
| C9 | 0160-5498 | 4 | 2 | CAPACITOR-FXD .01UF +-10% 100VDC CER | 28480 | 0180-3220 |
| C10 | 0160-1631 | 6 | 1 | CAPACITOR-FXD 1000PF +-10% 1KVDC CER | 28480 | 0180-3220 |
| C11 | 0160-5498 | 4 | 2 | CAPACITOR-FXD .01UF +-10% 100VDC CER | 28480 | 0180-3220 |
| A22 CR1 | 1902-0692 | 1 | 1 | DIODE-ZNR 6.3V 1% DO-7 PD=.4W TC=+.001% | 28480 | 1902-0692 |
| CR2 | 1901-0040 | 1 | 2 | DIODE-SWITCHING 30V 50MA 2NS DO-35 | 28480 | 1901-0040 |
| CR3 | 1901-0040 | 1 | 2 | DIODE-SWITCHING 30V 50MA 2NS DO-35 | 28480 | 1901-0040 |
| A22 Q1 | 1854-0358 | 3 | 2 | TRANSISTOR NPN SI PD=310MW FT=60MHZ | 28480 | 1854-0358 |
| Q2 | 1853-0080 | 6 | 2 | TRANSISTOR PNP SI PD=300MW FT=30MHZ | 28480 | 1853-0080 |
| Q3 | 1853-0080 | 6 | 2 | TRANSISTOR PNP SI PD=300MW FT=30MHZ | 28480 | 1853-0080 |
| Q4 | 1854-0358 | 3 | 2 | TRANSISTOR NPN SI PD=310MW FT=60MHZ | 28480 | 1854-0358 |
| Q5 | 1854-0523 | 4 | 1 | TRANSISTOR NPN SI TO-39 PD=1W FT=150MHZ | 28480 | 1854-0523 |
| Q6 | 1853-0037 | 3 | 1 | TRANSISTOR PNP SI TO-39 PD=1W FT=100MHZ | 28480 | 1853-0037 |
| A22 R1 | 1010-0629 | 9 | 1 | RESISTIVE NETWORK- DIP | 28480 | 1810-0629 |
| R2 | 1810-0625 | 5 | 1 | RESISTIVE NETWORK- DIP | 28480 | 1810-0625 |
| R3 | 1010-0302 | 5 | 1 | NETWORK-RES B-SIP47.0 OHM X 4 | 01121 | 208B470 |
| R4 | 0699-1020 | 7 | 1 | RESISTOR- 470 OHM 1% | 28480 | 0699-1020 |
| R5 | 0683-2255 | 9 | 1 | RESISTOR 2.2M 5% .25W FC TC=-900/+1100 | 01121 | CR2255 |
| R6 | 2100-3214 | 0 | 2 | RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN | 28480 | 2100-3214 |
| R7 | 2100-0567 | 0 | 1 | RESISTOR-TRMR 2K 10% C TOP-ADJ 1-TRN | 28480 | 2100-0567 |
| R8 | 2100-3214 | 0 | 2 | RESISTOR-TRMR 100K 10% C TOP-ADJ 1-TRN | 28480 | 2100-3214 |
| R9 | 0683-3355 | 2 | 1 | RESISTOR 3.3M 5% .25W FC TC=-900/+1100 | 01121 | CR3355 |
| R10 | 0683-1035 | 1 | 1 | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| A22 U1 | 1820-1730 | 6 | 2 | IC FF TTL LS D-TYPE POS-EDGE-TRIG COM | 01295 | SN74LS273N |
| U2 | 1820-1730 | 6 | 2 | IC FF TTL LS D-TYPE POS-EDGE-TRIG COM | 01295 | SN74LS273N |
| U3 | 1826-0485 | 9 | 1 | IC CONV 10-B-D/A 16-DIP-P PKG | 24355 | AD7530LN |
| U4 | 1826-0416 | 5 | 1 | IC SWITCH ANLG QUAD 16-DIP-C PKG | 27014 | LF13331D |
| U5 | 1826-0522 | 4 | 1 | IC OP AMP LOW-BIAS-H-IMPD QUAD 14-DIP-P | 01295 | TL074CN |
| U6 | 1826-0275 | 4 | 1 | IC 78L12A V RGLTR TO-92 | 04713 | MC78L12ACP |
| U7 | 1826-0282 | 3 | 1 | IC V RGLTR TO-92 | 04713 | MC79L12ACP |
| MISCELLANEDUS PARTS | | | | | | |
| | 2360-0113 | 2 | 2 | SCREW-MACH 6-32 .25-IN-LG PAN-HD-POZI | 00000 | ORDER BY DESCRIPTION |
| | 04276-00605 | 7 | 1 | PLATE (DC BIAS) | 28480 | 04276-00605 |

See introduction to this section for ordering information
 *Indicates factory selected value

Table 6-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|-----------------|
| 1 | 5040-7219 | | 2 | STRAP HANDLE CAP (FRONT) | | |
| 2 | 2680-0172 | | 4 | SCREW | | |
| 3 | 5060-9803 | | 2 | STRAP HANDLE | | |
| 4 | 2510-0192 | | 16 | SCREW | | |
| 5 | 5020-8836 | | 4 | STRUT | | |
| 6 | 04276-01202 | | 1 | ANGLE (POWER SWITCH) | | |
| 7 | 04274-40002 | | 3 | GUIDE (ANGLE) | | |
| 8 | 5060-9941 | | 2 | SIDE COVER | | |
| 9 | 5040-7220 | | 2 | STRAP HANDLE CAP (REAR) | | |
| 10 | 04276-01201 | | 1 | ANGLE | | |
| 11 | 3101-2216 | | 1 | LINE SWITCH | | |
| 12 | 0515-0150 | | 2 | SCREW | | |
| 13 | 3050-0235 | | 2 | WASHER | | |
| 14 | 9135-0084 | | 1 | LINE FILTER | | |
| 15 | 1400-0866 | | 1 | CABLE CLAMP | | |
| 16 | 2110-C360 | | 1 | FUSE .75A 250V (220/240V) SLOW BLOW | | |
| 17 | 2100-0007 | | 1 | FUSE 1A 250V (100/120V) SLOW BLOW | | |
| 18 | 2110-0565 | | 2 | FUSEHOLDER CAP | | |
| 19 | 04276-00603 | | 1 | BLANK PANEL (COMPARATOR/HANDLER INTERFACE) | | |
| 20 | 04276-66521 | | 1 | HP-IB BOARD | | |
| | 04276-00602 | | 1 | BLANK PANEL (INTERNAL DC BIAS) | | |
| 21 | 2360-0113 | | 10 | SCREW | | |
| 22 | 04276-04001 | | 1 | FAN COVER | | |
| 23 | 1250-0118 | | 2 | CONNECTOR-BNC | | |
| 24 | 2200-0105 | | 4 | SCREW | | |
| 25 | 6960-0001 | | 1 | CAP | | |
| 26 | 3160-0266 | | 1 | FAN | | |
| 27 | 2110-0011 | | 1 | FUSE 1/16A 250V | | |
| 28 | 2110-0564 | | 2 | FUSEHOLDER BODY | | |
| 29 | 2260-0009 | | 4 | NUT | | |
| 30 | 0360-1190 | | 1 | SOLDER TERMINAL | | |
| 31 | 2190-0016 | | 3 | WASHER | | |
| 32 | 2950-0001 | | 2 | NUT | | |
| 33 | 04276-00204 | | 1 | REAR PANEL | | |
| 34 | 2110-0569 | | 2 | FUSEHOLDER NUT | | |
| 35 | 3101-1877 | | 1 | DC BIAS SELECT SWITCH | | |
| 36 | 2360-0113 | | 8 | SCREW | | |
| 37 | 5020-8806 | | 1 | REAR FRAME | | |
| 38 | 5060-9834 | | 1 | TOP COVER | | |
| 39 | 04276-00102 | | 1 | CHASSIS (YELLOW) | | |
| 40 | 04276-00103 | | 1 | CHASSIS (RED) | | |
| 41 | 04276-00101 | | 1 | CHASSIS (BROWN) | | |
| 42 | 2360-0333 | | 6 | SCREW | | |
| 43 | 5020-8805 | | 1 | FRONT FRAME | | |
| 44 | 04276-00203 | | 1 | SUB PANEL | | |
| 45 | 04276-25001 | | 3 | WINDOW | | |
| 46 | 04276-00201 | | 1 | FRONT PANEL (HP) | | |
| | 04276-00202 | | 1 | FRONT PANEL (YHP) | | |
| 47 | 7120-1254 | | 1 | NAME PLATE (HP) | | |
| | 7120-0478 | | 1 | NAME PLATE (YHP) | | |
| 48 | 2950-0035 | | 4 | NUT | | |
| 49 | 5040-3324 | | 4 | INSULATOR-BNC | | |
| 50 | 1510-0038 | | 1 | BINDING POST | | |
| 51 | 04191-40001 | | 1 | GUIDE | | |
| 52 | 5040-3325 | | 4 | INSULATOR-BNC | | |
| 53 | 2190-0084 | | 1 | WASHER | | |
| 54 | 5000-4212 | | 4 | SOLDER TERMINAL | | |
| 55 | 2950-0006 | | 1 | NUT | | |
| 56 | 2190-0054 | | 4 | WASHER | | |
| 57 | 1250-0252 | | 4 | CONNECTOR-BNC | | |
| 58 | 1460-1345 | | 2 | STAND | | |
| 59 | 5040-7201 | | 4 | FOOT (BOTTOM) | | |
| 60 | 5060-9846 | | 1 | BOTTOM COVER | | |
| 61 | 5041-0564 | | 1 | KEY CAP | | |
| 62 | 04274-40001 | | 1 | ROD (POWER SWITCH) | | |
| 63 | 0160-4297 | | 4 | CAPACITOR 0.022 μ F | | |
| 64 | 1901-1065 | | 4 | DIODE | | |
| 65 | 0698-3634 | | 1 | RESISTOR 470 Ω | | |
| 66 | 0683-2245 | | 1 | RESISTOR 220k Ω | | |
| 67 | 0764-0016 | | 1 | RESISTOR 1k Ω | | |
| 68 | 1902-0657 | | 4 | DIODE | | |

See introduction to this section for ordering information



SECTION VII

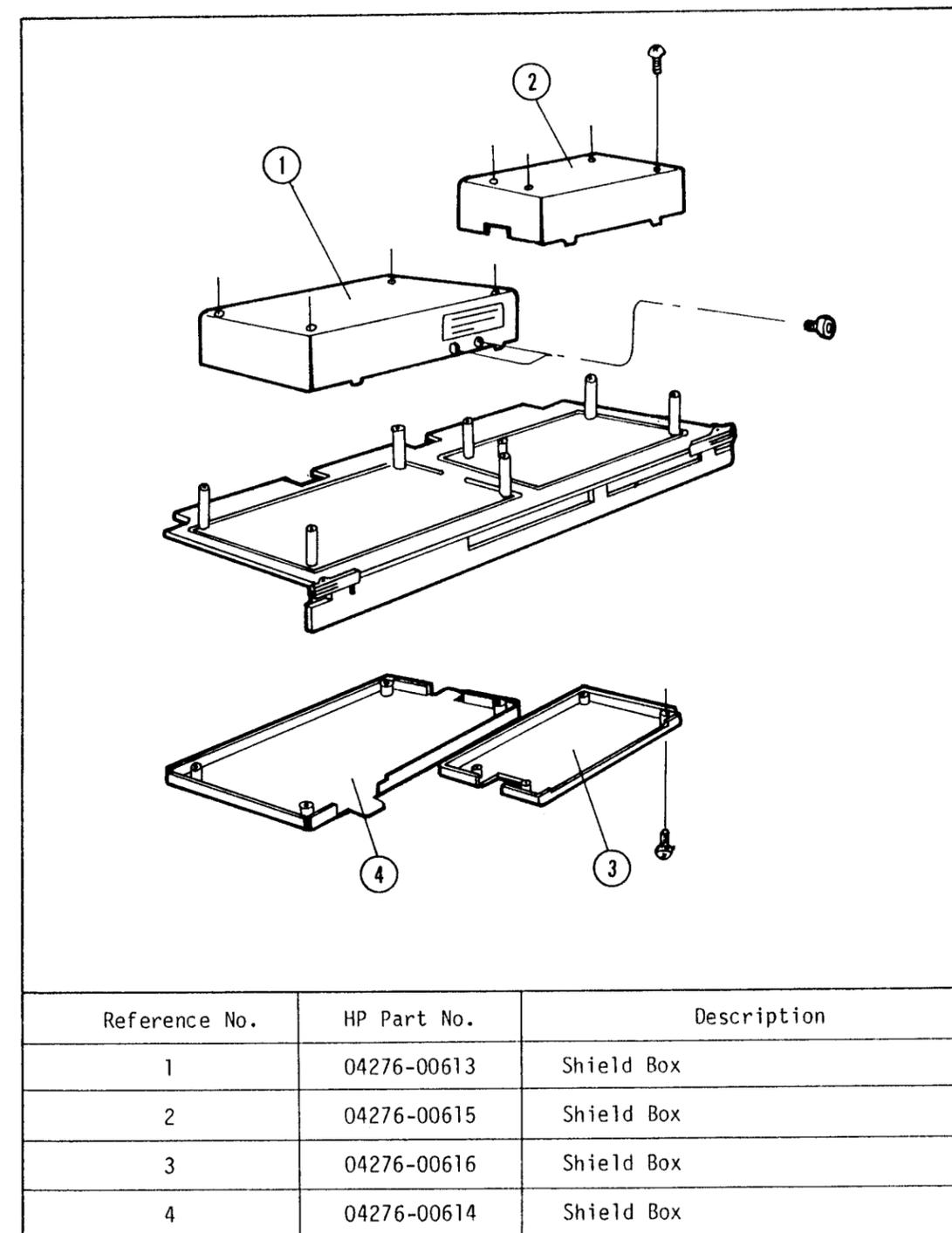


Figure 6-1. Shields on the A4 Board.

SECTION VII MANUAL CHANGES

7-1. INTRODUCTION

7-2. This section contains information for adapting this manual to instruments for which the content does not directly apply. The following paragraphs explain how to adapt this manual to apply to an older instrument with a serial prefix lower than that given on the title page.

7-3. MANUAL CHANGES

7-4. To adapt this manual to your instrument, refer to Table 7-1 and make all of the manual changes listed opposite your instrument serial number. Perform these changes in the sequence listed.

7-5. If your instrument serial number is not listed on the title page of this manual or in Table 7-1, it may be documented in a yellow MANUAL CHANGES supplement. For additional information about serial number coverage, refer to INSTRUMENTS COVERED BY MANUAL in Section I.

Table 7-1. Manual Changes by Serial Number

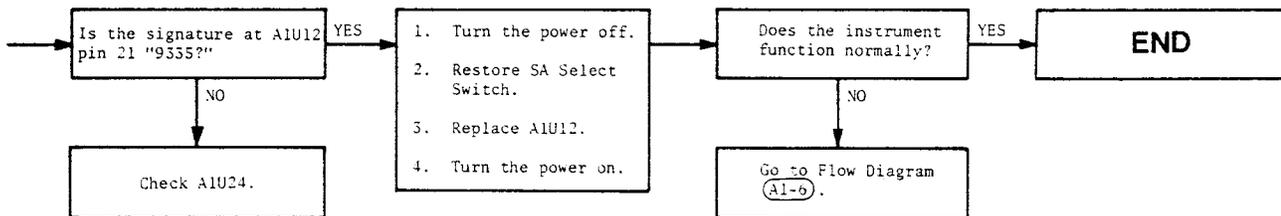
| Serial Prefix or Number | Make Manual Changes |
|-------------------------------|---------------------|
| 2227J00101 thru 2227J00155 | 1 |

CHANGE 1

Section VIII, Troubleshooting Flow Diagram A1-5:
Change Signature Sets 5-4, 5-6, and 5-11 as follows:

| Signature Set 5-4 | | Signature Set 5-11 | | Signature Set 5-6 | |
|-------------------|------|--------------------|------|-------------------|------|
| A1J1 pin 9 | 3388 | A1U10 pin 9 | 8415 | A1U5 pin 9 | 0512 |
| pin 10 | A9FP | pin 10 | 5193 | pin 10 | 5UA2 |
| pin 11 | 3190 | pin 11 | U083 | pin 11 | AU44 |
| pin 12 | AF81 | pin 13 | 2H2F | pin 13 | 9693 |
| pin 13 | 50A4 | pin 14 | 7A72 | pin 14 | U762 |
| pin 14 | 4H45 | pin 15 | 3PU8 | pin 15 | 9911 |
| pin 15 | A07C | pin 16 | 62A2 | pin 16 | F79P |
| pin 16 | 6UC0 | pin 17 | CFF2 | pin 17 | U0P0 |

Partially change the flow diagram as follows :



SECTION VIII

SERVICE

8-1. INTRODUCTION

8-2. This section provides the information and instructions required to service the Model 4276A LCZ Meter. Included are Theory of Operation and Troubleshooting Guide with Circuit Schematics. The Theory of Operation describes fundamental principles and circuit operating theory of the 4276A with block diagrams. Circuit schematics, locator illustrations, troubleshooting guide and other technical data necessary for repairs are integrated into the service sheet foldouts. An illustration of the instrument interior is shown in Figure 8-27.

8-3. SAFETY CONSIDERATIONS

8-4. This section contains warnings and cautions that must be followed for your protection and to avoid damage to the instrument.

WARNING

MAINTENANCE DESCRIBED HEREIN IS PERFORMED WITH POWER SUPPLIED TO THE INSTRUMENT AND PROTECTIVE COVERS REMOVED. SUCH MAINTENANCE SHOULD BE PERFORMED ONLY BY SERVICE-TRAINED PERSONNEL AWARE OF THE HAZARDS INVOLVED (FOR EXAMPLE, FIRE AND ELECTRICAL SHOCK). WHERE MAINTENANCE CAN BE PERFORMED WITHOUT POWER APPLIED, THE POWER SHOULD BE REMOVED. BEFORE ANY REPAIR IS COMPLETED, ENSURE THAT ALL SAFETY FEATURES ARE INTACT AND FUNCTIONING AND THAT ALL NECESSARY PARTS ARE CONNECTED TO THEIR MEANS OF PROTECTIVE GROUNDING.

8-5. THEORY OF OPERATION

8-6. The theory of operation discussion is organized into two sections: basic theory and block diagram discussion. The basic theory, beginning with paragraph 8-13, explains the concepts and fundamental theory of the 4276A adapted for accurately measuring the DUT and for achieving automated measurements. The

block diagram discussion describes the overall circuit operating theory of the 4276A with block-to-block signal flow. Also included are block and timing diagrams.

8-7. RECOMMENDED TEST EQUIPMENT

8-8. The test equipment required to the perform operations outlined in this section is listed in Table 4-1. The table includes type of instrument required, critical specifications, use, and recommended model. If the recommended model is not available, equipment which meets or exceeds the critical specifications listed may be substituted.

8-9. TROUBLESHOOTING

8-10. The troubleshooting guide provides instructions and information for locating a faulty circuit component. All instructions consider the safety of service personnel performing the procedures. The diagnostic guides are in the form flow diagrams. The board level troubleshooting diagrams are used to isolate failures to an individual malfunctioning circuit board assembly. The guides for locating a defective component are given on the individual board service-sheets and integrate service support data—test point locations, waveform illustrations, voltage data, timing diagrams, and other technical information in addition to providing schematic diagrams for each board. To facilitate troubleshooting of the 4276A Digital Section, the troubleshooting guide for the logic circuits uses signature analysis.

8-11. REPAIR

8-12. Repair explanations tell how to replace defective circuit components. The recommended replacement procedures for components and parts which require special repair, replacement tools, or test equipment should be observed. To prevent damage resulting from improper repair procedure, refer to the appropriate manual section before proceeding with repair.

8-13. BASIC THEORY

8-14. The 4276A applies a sinusoidal voltage to the device under test and detects the resulting complex voltage, \dot{V} , and complex current, \dot{I} . The instrument then converts \dot{V} and \dot{I} into their individual orthogonal components to obtain the DUT's resistance, R , and reactance, X .

$$\dot{V} = a + jb$$

$$\dot{I} = c + jd$$

$$R = \frac{ac + bd}{c^2 + d^2}$$

$$X = \frac{bc - ad}{c^2 + d^2}$$

Once the values of R and X are known, all other impedance parameters-- C , L , D , Q , ESR , G , $|Z|$, and θ can be calculated. Refer to Table 8-1.

8-15. A simplified drawing of the circuit used to detect \dot{V} and \dot{I} is shown in Figure 8-1. In the figure, $\dot{V} = e_{DUT}$ and $\dot{I} = e_{RR} / -R_{RR}$, where e_{DUT} is the voltage across the DUT, e_{RR} the output voltage from the I/V converter, and R_{RR} is the value of the range resistor.

All measurement parameters are calculated from the two vector voltages e_{DUT} and e_{RR} .

Table 8-1. Impedance Parameter Conversion Equations

| Parameter | Equation |
|-----------|------------------|
| C | $-1/2\pi fX$ |
| L | $X/2\pi f$ |
| D | R/X |
| Q | X/R |
| ESR | R |
| G | $R/(R^2 + X^2)$ |
| $ Z $ | $R^2 + X^2$ |
| θ | $\tan^{-1}(X/R)$ |

f = test frequency

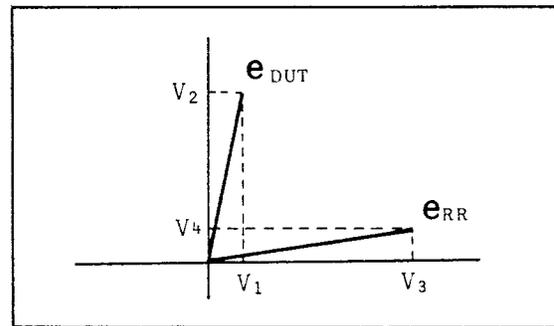


Figure 8-2. Vector Voltages.

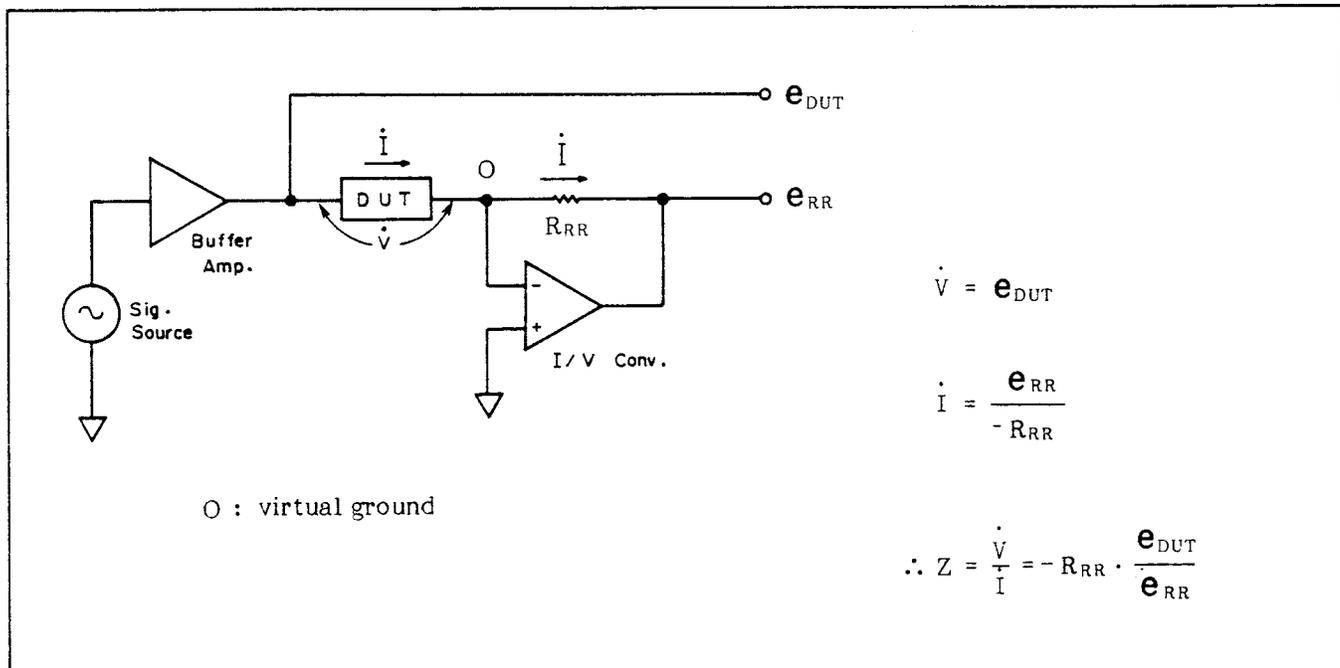


Figure 8-1. e_{DUT} and e_{RR} Detection.

8-16. The 4276A alternately detects e_{DUT} and e_{RR} , and converts them into their orthogonal (real and imaginary) voltage components.

$$e_{DUT} = V_1 + jV_2$$

$$e_{RR} = V_3 + jV_4$$

To obtain R and X, the 4276A measures three voltage ratios: α , β , and γ . Refer to Table 8-2. R and X, the primary impedance parameters, are calculated from α , β , and γ using the equations listed in Table 8-3.

Table 8-2. Voltage Ratios

| Voltage Ratio | e_{DUT} / e_{RR} Component |
|---------------|------------------------------|
| α | V_4/V_3 |
| β | V_2/V_3 |
| γ | V_1/V_2^* |

* For ESR and G measurements, γ is V_1/V_3 .

8-17. As long as the DUT's D value, which nearly equals γ , is less than 0.01, the product of α and γ will be approximately zero, $\alpha\gamma \approx 0$, because α is always small. Thus, reactance, X, can be obtained by measuring β only. All three voltage ratios— α , β , and γ --are measured when the 4276A is set to C, L, or $|Z|$ measurement mode. When HIGH SPEED C or HIGH SPEED L is selected, however, α and γ are not measured, thereby shortening the time required for measurement.

8-18. The voltage ratios are measured using dual-slope integration. Refer to Figure 8-3. The integrator is charged by voltage V_A for a constant time T_A ($\approx 5ms$), and is then discharged by voltage V_B . The ratio V_A/V_B is obtained by measuring the time required to discharge the integrator. In this example, voltages V_A and V_B can be any of the orthogonal voltages of e_{RR} or e_{DUT} ; that is, V_1, V_2, V_3 , or V_4 .

8-19. When measurement is made on the high impedance ranges—those ranges enclosed by the bold line in Figure 8-4--the 4276A measures admittance parameters G and B instead of R and X in order to provide optimum accuracy.

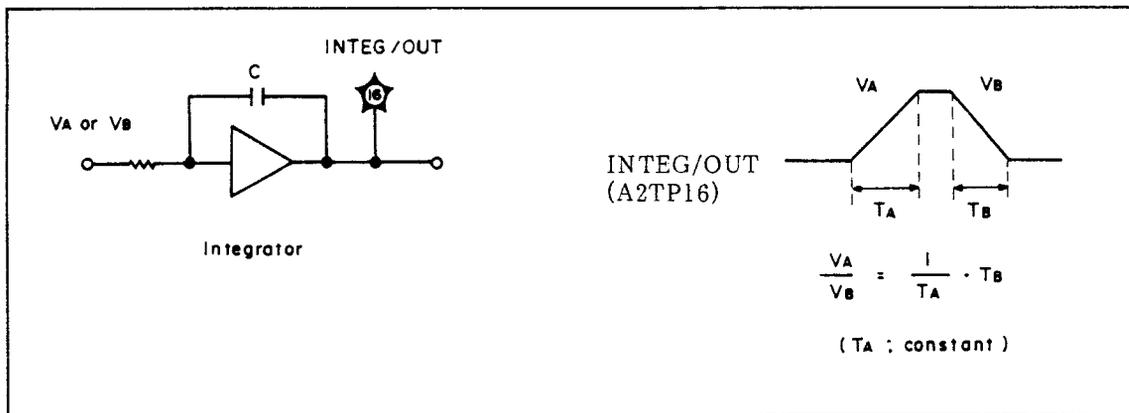


Figure 8-3. Voltage Ratio Detection

Table 8-3. Voltage Ratio Equations

| DISPLAY A Function | DISPLAY B Function | Impedance Parameter | Voltage Ratio Equation |
|--------------------|--------------------|---------------------|--|
| C, L | D, Q | X | $- R_{RR} \cdot \beta (1 - \alpha\gamma)/(1 + \alpha^2)$ |
| | | R/X (= D) | $(\alpha + \gamma)/(1 - \alpha\gamma)$ |
| C, L, $ Z $ | ESR, G, θ | X | $- R_{RR} \cdot (\beta - \alpha\gamma)/(1 + \alpha^2)$ |
| | | R | $- R_{RR} \cdot (\alpha\beta + \gamma)/(1 + \alpha^2)$ |

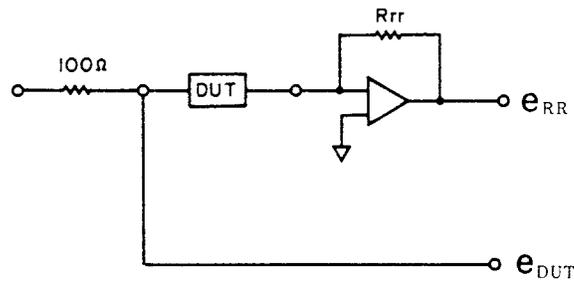
e_{RR} and e_{DUT}

e_{RR} and e_{DUT} are voltages across the range resistor and the DUT, respectively. Each voltage is calculated from the following equations:

$$e_{DUT} = \frac{|Z|}{100 + |Z|} \cdot 1V_{rms}$$

$$e_{RR} = \frac{e_{DUT}}{|Z|} \cdot R_{RR} = \frac{R_{RR}}{100 + |Z|} \cdot 1V_{rms}$$

where, $|Z|$ and R_{RR} are the DUT's impedance value and the range resistor value, respectively. It is obvious that both e_{DUT} and e_{RR} depend on the DUT's impedance value. The instrument amplifies the voltage which is smaller, e_{RR} or e_{DUT} , so as to input an appropriate level signal to the VRD. This is necessary because a small signal cannot be detected in the VRD with high accuracy and resolution.



| DUT Impedance | e_{RR} | e_{DUT} |
|-------------------|----------|-----------|
| $ Z < 100\Omega$ | | |
| $ Z > 100\Omega$ | | |

When the DUT's impedance is less than 100Ω , e_{DUT} is smaller than e_{RR} , which is amplified by the AM1 and AM2 circuits in the Process Amplifier. Conversely, when the DUT's impedance is more than 100Ω , e_{RR} is smaller than e_{DUT} , which is amplified in the range resistor circuit by changing the range resistor value, and also in the AM1 and AM2 circuits if necessary.

Figure 8-4. e_{RR} and e_{DUT} .

Z/Y Measurement Modes

When the measurement range is set to a range suitable for measuring a DUT whose impedance value is less than 100Ω , the instrument measures the impedance parameters R and X (Z measurement mode). When the measurement range is set to a higher range, however, the instrument measures the admittance parameters G and B (Y measurement mode). Refer to Figure A. In either measurement mode, the instrument calculates the selected measurement parameter, C, L, etc., from the measured parameter values.

Note

A DUT whose impedance is 100Ω is measured in Y measurement mode on some ranges.

Table A. Capacitance Measurement

| C Range | Test Frequency (100Hz to 20kHz) | |
|-------------|---------------------------------|------|
| | 200Hz | 2kHz |
| 10mF | Z Measurement | |
| 1mF | | |
| 100 μ F | | |
| 10 μ F | | |
| 1 μ F | | |
| 100 μ F | Y Measurement | |
| 10mF | | |
| 1 μ F | | |
| 100pF | | |
| 10pF | | |
| 1pF | | |

Table B. Inductance Measurement

| L Range | Test Frequency (100Hz to 20kHz) | |
|-------------|---------------------------------|-------|
| | 1kHz | 10kHz |
| 1kH | Y Measurement | |
| 100H | | |
| 10H | | |
| 1H | | |
| 100mH | Z Measurement | |
| 10mH | | |
| 1mH | | |
| 100 μ H | | |
| 10 μ H | | |

Figure 8-5. Z/Y Measurement Modes (Sheet 1 of 4).

(1) Z Measurement Mode

When the DUT's impedance value is lower than 100Ω , the current through the DUT, I in Figure B, is approximately constant. Thus, the voltage, e_{RR} , across the range resistor, is also approximately constant because e_{RR} is the product of R_{RR} and I.

In this case, impedance parameter measurement is more accurate than admittance parameter measurement. Therefore, the instrument measures R and X.

$$Z = e_{DUT}/I = R_{RR} \cdot (e_{DUT}/e_{RR})$$

In D or Q measurement mode, the instrument measures D (= R/X) directly.

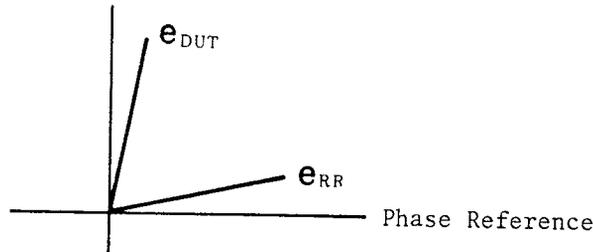


Table D. Measurement Parameters Relation in Z Mode

| Measurement Functions | CKT MODE | DISPLAY A Value | DISPLAY B Value | Measured Parameters |
|-----------------------|----------|-----------------------------|----------------------------|---------------------|
| L-D | | $L = X/2\pi f$ | D = D | X, D |
| | | $L = X (1 + D^2)/2\pi f$ | D = D | X, D |
| L-Q | | $L = X/2\pi f$ | Q = 1/D | X, D |
| | | $L = X (1 + D^2)/2\pi f$ | Q = 1/D | X, D |
| L-ESR/G | | $L = X/2\pi f$ | ESR = R | X, R |
| | | $L = (X^2 + R^2)/2\pi f X$ | G = R/(R^2 + X^2) | X, R |
| C-D | | $C = -1/2\pi f X$ | D = -D | X, D |
| | | $C = -1/2\pi f X (1 + D^2)$ | D = -D | X, D |
| C-Q | | $C = -1/2\pi f X$ | Q = -1/D | X, D |
| | | $C = -1/2\pi f X (1 + D^2)$ | Q = -1/D | X, D |
| C-ESR/G | | $C = -1/2\pi f X$ | ESR = R | X, R |
| | | $C = -X/2\pi f (R^2 + X^2)$ | G = R/(R^2 + X^2) | X, R |
| Z - θ | | $ Z = \sqrt{R^2 + X^2}$ | $\theta = \tan^{-1} (X/R)$ | X, R |
| | | | | |

Figure 8-5. Z/Y Measurement Modes (Sheet 3 of 4).

(2) Y Measurement Mode

When the DUT's impedance value is higher than 100Ω, the voltage across the DUT, e_{DUT} , is approximately constant, as shown in Figure B.

In this case, admittance parameter measurement is more accurate than impedance parameter measurement. Therefore, the instrument measures G and B.

$$Y = I/e_{DUT} = (1/R_{RR}) \cdot (e_{RR}/e_{DUT})$$

In D or Q measurement mode, the instrument measures D (= R/X) directly.

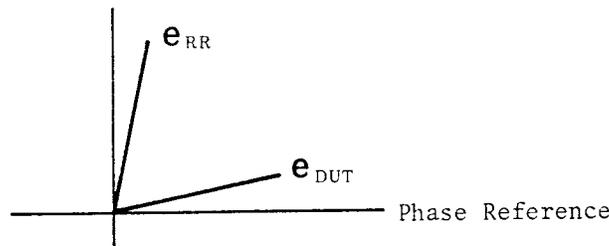


Table E Measurement Parameters Relation in Y Mode

| Measurement Functions | CKT MODE | DISPLAY A Value | DISPLAY B Value | Measured Parameters |
|-----------------------|----------|-----------------------------|-----------------------------|---------------------|
| L-D | | $L = -1/2\pi fB (1 + D^2)$ | $D = D$ | B, D |
| | | $L = -1/2\pi fB$ | $D = D$ | B, D |
| L-Q | | $L = -1/2\pi fB (1 + D^2)$ | $Q = 1/D$ | B, D |
| | | $L = -1/2\pi fB$ | $Q = 1/D$ | B, D |
| L-ESR/G | | $L = -B/2\pi f (G^2 + B^2)$ | $ESR = G/(G^2 + B^2)$ | B, G |
| | | $L = -1/2\pi fB$ | $G = G$ | B, G |
| C-D | | $C = B (1 + D^2)/2\pi f$ | $D = D$ | B, D |
| | | $C = B/2\pi f$ | $D = D$ | B, D |
| C-Q | | $C = B (1 + D^2)/2\pi f$ | $Q = 1/D$ | B, D |
| | | $C = B/2\pi f$ | $Q = 1/D$ | B, D |
| C-ESR/G | | $C = (G^2 + B^2)/2\pi fB$ | $ESR = G/(G^2 + B^2)$ | B, G |
| | | $C = B/2\pi f$ | $G = G$ | B, G |
| $ Z - \theta$ | | $ Z = 1/\sqrt{G^2 + B^2}$ | $\theta = \tan^{-1} (-B/G)$ | B, G |
| | | | | |

Figure 8-5. Z/Y Measurement Modes (Sheet 4 of 4).

e_{ref} and e_{test}

The instrument measures the ratio between two vector voltages: e_{DUT} (voltage across the DUT) and e_{RR} (voltage across the range resistor). In Z measurement mode, the vector voltage ratio is e_{DUT}/e_{RR} , and in Y measurement mode, e_{RR}/e_{DUT} .

e_{test} and e_{ref} are defined as the numerator and the denominator of the detected ratio, respectively. The relations among e_{test} , e_{ref} , e_{DUT} , and e_{RR} are described in Table A.

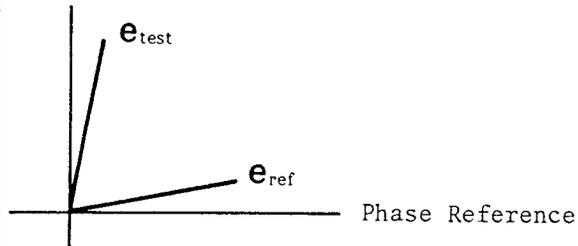


Table A.

| Measurement Mode | e_{test} | e_{ref} |
|------------------|------------|-----------|
| Z | e_{DUT} | e_{RR} |
| Y | e_{RR} | e_{DUT} |

Figure 8-6. e_{ref} and e_{test} .

HIGH SPEED C/L MEASUREMENT PRINCIPLE

The instrument measures the selected impedance parameters—C, L, D, Q, etc.—by detecting three voltage ratios— α , β , and γ —and calculating each parameter from the equations listed in Table A of Figure 8-7. Voltage ratio α is always close to zero because the phase reference signal used by the phase detector is nearly in-phase with or 90° out of phase with e_{ref} . Also, when γ is much smaller than 1, only β is necessary to obtain C or L. Therefore, if the dissipation factor, D, of the DUT is much lower than 1, voltage ratios α and γ need not be detected to obtain C or L, significantly reducing total measurement time. In HIGH SPEED C or HIGH SPEED L measurement mode, the instrument detects only β .

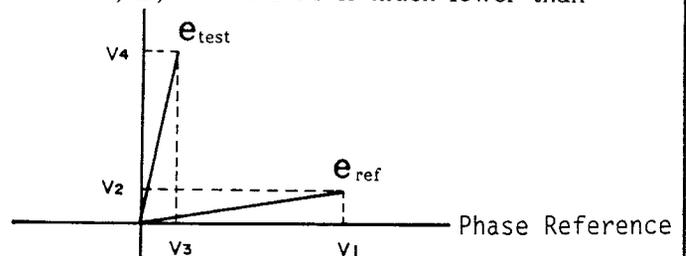


Table A.

| Measurement Mode | Measured Parameters | Parameter Equation | Voltage Ratio | | |
|------------------|---------------------|---|---------------|-----------|-----------|
| | | | α | β | γ |
| Z | X, D | $X = -R_{RR} \cdot \beta (1 - \alpha\gamma) / (1 + \alpha^2)$ | V_2/V_1 | V_4/V_1 | V_3/V_4 |
| | | $D = (\alpha + \gamma) / (1 - \alpha\gamma)$ | | | |
| | X, R | $X = -R_{RR} \cdot (\beta - \alpha\gamma) / (1 + \alpha^2)$ | V_2/V_1 | V_4/V_1 | V_3/V_1 |
| | | $R = -R_{RR} \cdot (\alpha\beta + \gamma) / (1 + \alpha^2)$ | | | |
| Y | B, D | $B = -G_{RR} \cdot \beta (1 - \alpha\gamma) / (1 + \alpha^2)$ | V_2/V_1 | V_4/V_1 | V_3/V_4 |
| | | $D = -(\alpha + \gamma) / (1 - \alpha\gamma)$ | | | |
| | B, G | $B = -G_{RR} \cdot (\beta - \alpha\gamma) / (1 + \alpha^2)$ | V_2/V_1 | V_4/V_1 | V_3/V_1 |
| | | $G = -G_{RR} \cdot (\alpha\beta + \gamma) / (1 + \alpha^2)$ | | | |

$(\hat{Y} = 1/\hat{Z}, \hat{Z} = R + jX, \hat{Y} = B + jX, D = R/X, D = -G/B)$

Figure 8-7. HIGH SPEED C/L Measurement Principle

SECTION VIII

8- 20. ANALOG SECTION BLOCK LEVEL THEORY

8- 21. The following paragraphs describe the structure and operation of the 4276A's Analog Section. The Analog Section consists of the Signal Source, the Transducer, the Process Amplifier, and the Vector Ratio Detector (VRD). The block diagram of the Analog Section is shown in Figure 8-8. The simplified block diagram of the Analog Section is shown in Figure 8-8.

8- 22. SIGNAL SOURCE

8- 23. The block diagram of the Signal Source is shown in Figure 8-9 . The Signal Source consists of a crystal oscillator, a phase-locked loop (PLL), a quasi-sinewave oscillator, low-pass filters, and an attenuator.

8- 24. The crystal oscillator (located on the A1 board) outputs a precise 11.5200MHz signal which is divided down to provide an 8kHz reference signal for the phase detector in the PLL, a 5.760MHz clock signal for the Z80 microprocessor, and other clock signals for the various digital operations performed by the instrument.

8- 25. The voltage-controlled oscillator (VCO) in the PLL outputs an 8MHz to 20MHz signal, which is divided down to a 16F signal for test frequency generation. The output frequency of the VCO is determined by the phase detector, the loop filter, and the $\div N$ divider. If the frequency of the signal output from the $\div N$ divider is different from the 8kHz of the reference signal from the crystal oscillator, the phase detector will output an "unlock" signal to the loop filter, which will then adjust the VCO

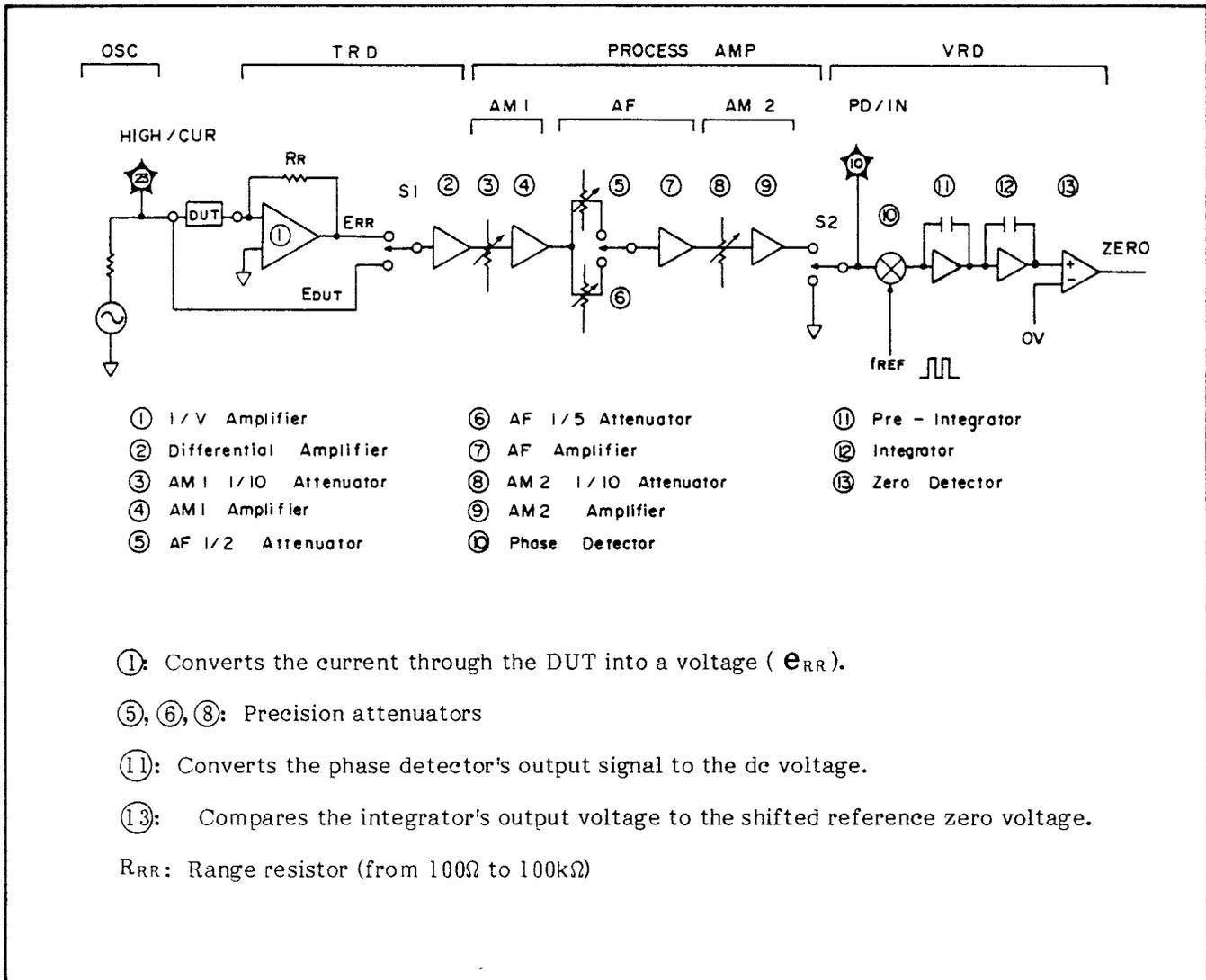


Figure 8-8 . Simplified Analog Section Block Diagram.

Model 4276A

control voltage up or down until the PLL is locked. The VCO control voltage is between -10V and +10V; the N divisor is from 100 to 250. The PLL is locked when NFVCO is 8kHz.

8-26. The quasi-sinewave oscillator generates a digital sinewave whose fundamental frequency is the same as the test frequency. This oscillator consists of a 16-bit counter, a ROM, and a DA converter. The 16-bit counter counts the pulses of the 16F signal sent from the PLL. The counter's outputs are connected to the address-select lines of the ROM. The ROM contains digital data which determines the output from the DA converter. The digital data and the addresses are arranged so that, as the ROM is addressed by the 16-bit counter, the output from the DA converter will be a rising

and falling staircase waveform. The DA converter's output is filtered by a low-pass filter, leaving a clean 1Vrms sinewave. Signal level is controlled by an attenuator and a buffer amplifier. When HIGH SIG LEVEL is selected on the front panel, the 1Vrms signal is not attenuated; when LOW SIG LEVEL is selected, the test signal level is attenuated to 50mVrms. On certain measurement ranges, the 1Vrms signal level is amplified to 2Vrms.

8-27. The source resistor, R_s in Figure 8-9, is a 47Ω fuse resistor which protects the instrument from damage if a charged capacitor is connected to the UNKNOWN terminals.

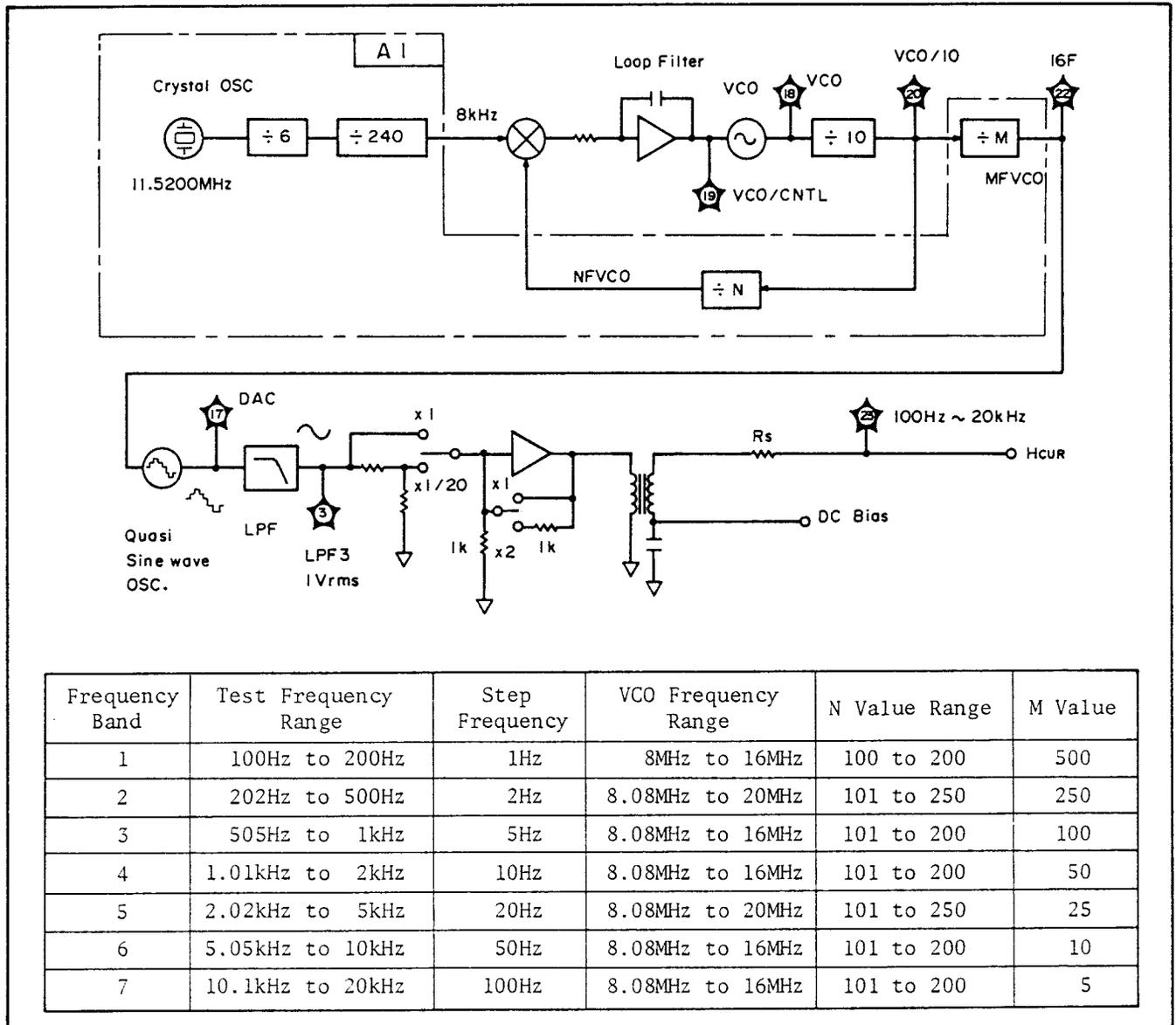


Figure 8-9 . Signal Source Block Diagram.

Quasi-Sinewave Oscillator

The quasi-sinewave oscillator consists of a modulo-16 counter, a ROM, and a digital-to-analog converter, as shown in Figure A. The oscillator outputs a digital sinewave, which, once filtered, becomes the instrument's test signal. The circuit works as follows.

The counter, A2U32, counts the pulses of a 16F squarewave sent from the phase-locked loop. The counter's outputs are connected directly to the ROM's lower-four address control lines. As the counts changes, a different address is selected and the binary number at the selected address is output to the digital-to-analog converter. Output from the digital-to-analog converter is a dc voltage proportional to the binary number output from the ROM. The address sequence and the data stored in the ROM are such that the output from the digital-to-analog resembles a sine wave. The relationships among the ROM addresses, stored data, and output voltage are listed in Table A. Figure B shows the timing diagram of the circuit.

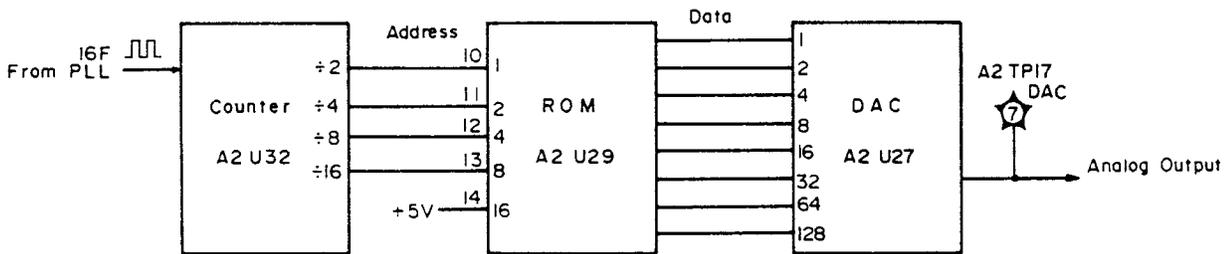


Figure A. Quasi-Sinewave Oscillator Circuit.

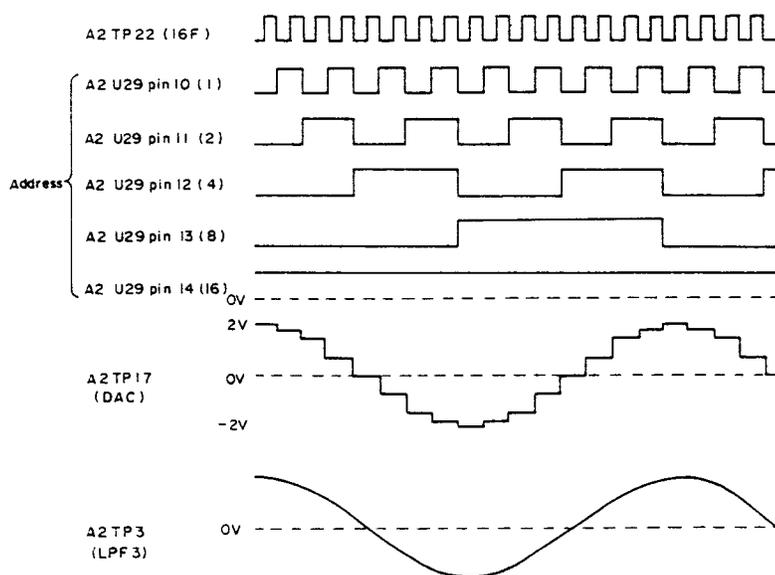


Table A. ROM Data

| Address | Data | A2TP17 |
|---------|------|--------|
| 16 | 255 | 2V |
| 17 | 245 | 1.92V |
| 18 | 218 | 1.71V |
| 19 | 176 | 1.58V |
| 20 | 128 | 0V |
| 21 | 79 | -1.38V |
| 22 | 38 | -1.71V |
| 23 | 10 | -1.92V |
| 24 | 0 | -2V |
| 25 | 10 | -1.92V |
| 26 | 38 | -1.71V |
| 27 | 79 | -1.38V |
| 28 | 128 | 0V |
| 29 | 176 | 1.58V |
| 30 | 218 | 1.71V |
| 31 | 245 | 1.92V |

Figure B. Timing Diagram.

Figure 8-10. Quasi-Sinewave Oscillator.

Model 4276A

8-28. TRANSDUCER

8-29. A simplified schematic of the Transducer is shown in Figure 8-11. The transducer detects two vector voltage, e_{DUT} and e_{RR} , and alternately selects each for output to the voltage ratio detector (VRD) through the process amplifier. e_{DUT} is the voltage across the DUT. e_{RR} is the voltage across the range resistor in the feedback loop of the I/V converter amplifier. Since the current flowing through the DUT must also flow through the range resistor, e_{RR} is proportional to the current. There are four range resistors: 100Ω , $1k\Omega$, $10k\Omega$, and $100k\Omega$. Measurement range is determined by the range resistor and the gain of the AM circuit in the process amplifier. e_{DUT} and e_{RR} are both detected by a precision differential amplifier.

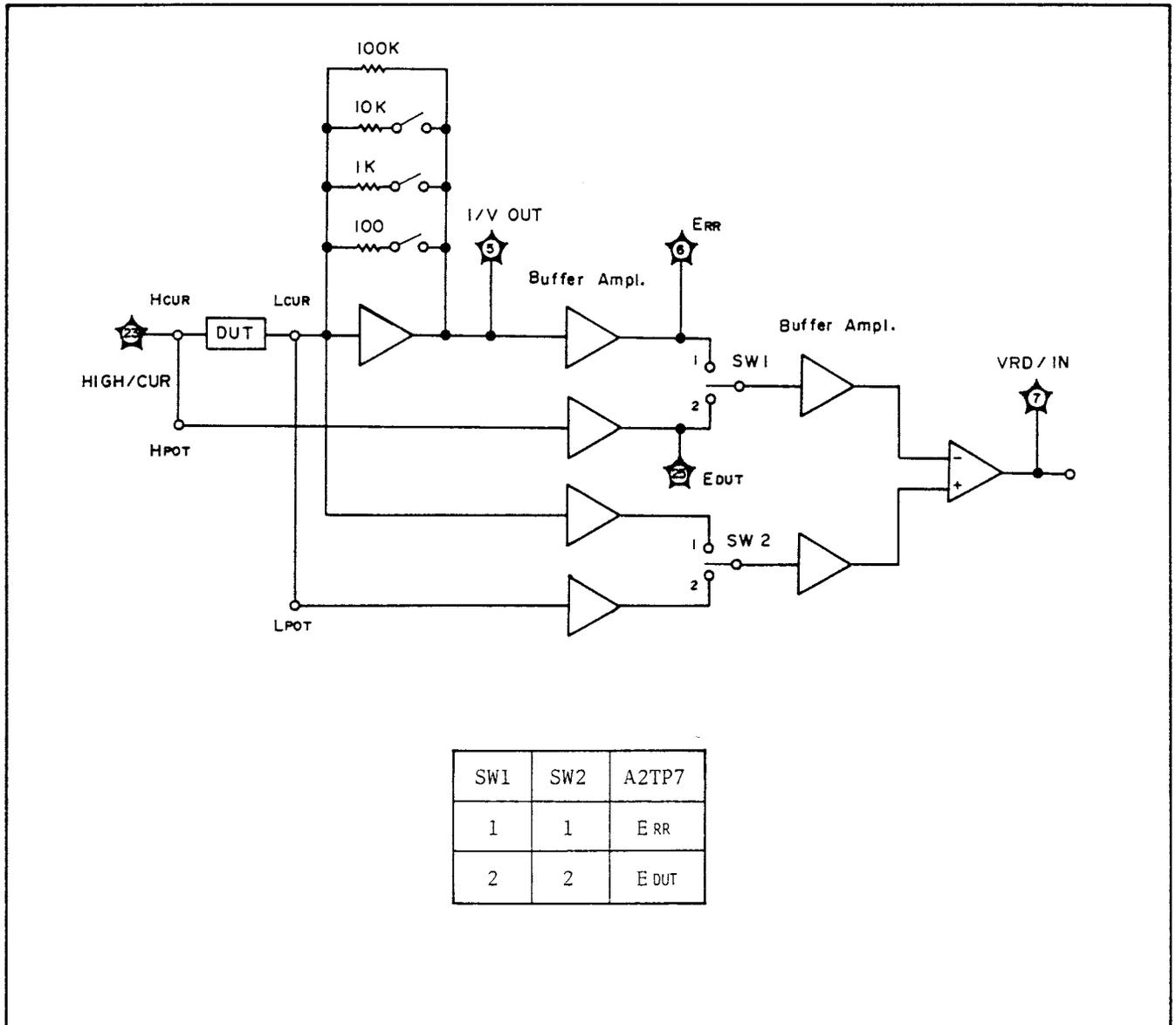


Figure 8-11. Transducer Block Diagram.

SECTION VIII

8-30. PROCESS AMPLIFIER

8-31. When the DUT's impedance is much lower than 100Ω , the level of the e_{DUT} signal is much lower than that of the e_{RR} signal ($\approx 1V_{rms}$). When the DUT's impedance is much higher than 100Ω , the level of the e_{RR} signal is much lower than that of the e_{DUT} signal ($\approx 1V_{rms}$).

The process amplifier controls the signal levels of e_{DUT} and e_{RR} so that they are roughly equal; thereby improving resolution in the VRD section. The process amplifier consists of three stages--AM1, AF, and AM2--as shown in Figure 8-12. The AM1 and AM2 stages compensate for signal level differences between e_{DUT} and e_{RR} caused by measurement range selection. The AF stage compensates for signal level differences caused by test frequency selection. Each stage contains an amplifier to roughly magnify the signal level and an attenuator to precisely attenuate the signal. In one measurement cycle,

the amplifiers magnify both e_{DUT} and e_{RR} by the same gain factor. On the other hand, however, the attenuators attenuate e_{DUT} and e_{RR} by different attenuation factors, depending on the DUT's impedance. Therefore, the difference of amplitudes for e_{DUT} and e_{RR} is determined by the precise attenuators contained in AM1/AF/AM2 circuits. It is important that the common amplification of e_{DUT} and e_{RR} have no effect on voltage detection because the instrument detects the voltage ratios of the quadrature components of e_{DUT} and e_{RR} in the VRD section.

8-32. Figures 8-13 and 8-14 show the AM and the AF controls, respectively.

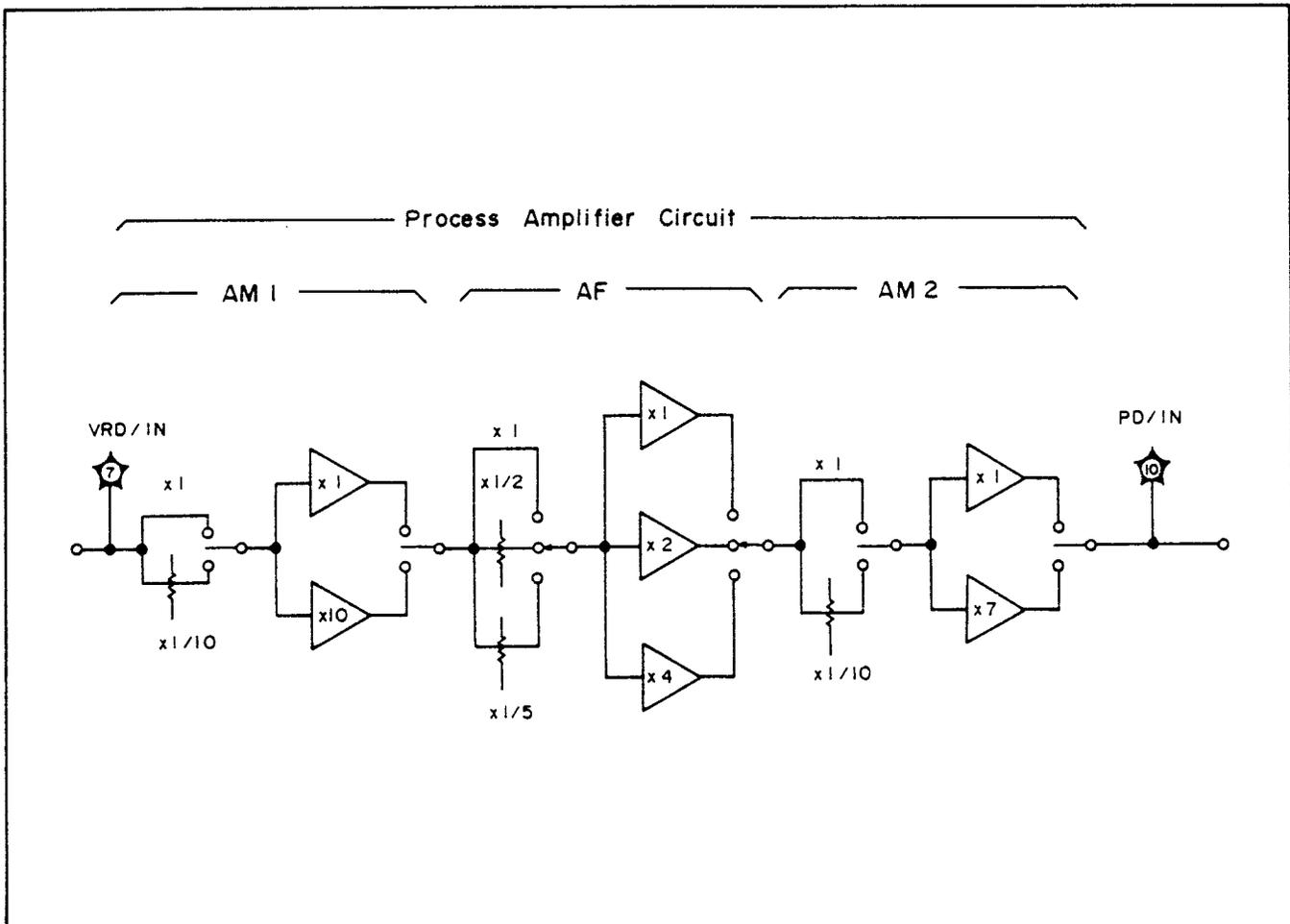


Figure 8-12. Process Amplifier Block Diagram

Table AF Control

| Test Frequency Range [Hz] | C Measurement | | L Measurement | | Z Measurement | |
|---------------------------|---------------|--------|---------------|--------|---------------|--------|
| | Z Mode | Y Mode | Z Mode | Y Mode | Z Mode | Y Mode |
| 100 to 199 | F0 | F0 | F0 | F0 | F0 | F0 |
| 200 to 498 | F5 | F2 | F4 | F1 | | |
| 500 to 995 | F4 | F1 | F5 | F2 | | |
| 1k to 1.99k | F0 | F0 | F0 | F0 | | |
| 2k to 4.98k | F5 | F2 | F4 | F1 | | |
| 5k to 9.95k | F4 | F1 | F5 | F2 | | |
| 10k to 20k | F0 | F0 | F0 | F0 | | |

Table AF Gain

| AF Code | (Gt) | | (Gr) | | Gain Ratio (Gt/Gr) |
|---------|-------|-----|-------|-----|--------------------|
| | ATT | AMP | ATT | AMP | |
| F0 | x 1 | x 1 | x 1 | x 1 | 1 |
| F1 | x 1 | x 2 | x 1/2 | x 2 | 2 |
| F2 | x 1 | x 4 | x 1/5 | x 4 | 5 |
| F3 | x 1 | x 4 | x 1 | x 4 | 1 |
| F4 | x 1/2 | x 1 | x 1 | x 1 | 1/2 |
| F5 | x 1/5 | x 1 | x 1 | x 1 | 1/5 |
| F6 | x 1/5 | x 2 | x 1/2 | x 2 | 2/5 |
| F7 | x 1 | x 1 | x 1/5 | x 1 | 5 |

Figure 8-14. AF Control.

Model 4276A

8-33. VECTOR RATIO DETECTOR (VRD)

8-34. A simplified circuit diagram of the VRD is shown in Figure 8-15. The VRD consists of a phase detector, a pre-integrator, an integrator, and a zero detector. The VRD's function is to measure the three voltage ratios— α , β , and γ —from which all measurement parameters are derived.

8-35. The phase detector is switched by two signals— $e_{ref}(0^\circ)$ and $e_{ref}(90^\circ)$ —which convert the input signals— e_{ref} and e_{test} —into their orthogonal components. Thus, the phase detector outputs four voltages: $e_{ref}(0^\circ)$, $e_{ref}(90^\circ)$, $e_{test}(0^\circ)$, and $e_{test}(90^\circ)$. The pre-integrator integrates the phase detector output voltage for 5ms at test frequencies of 200Hz and above, or for one test signal period up to 10ms at frequencies below 200Hz. The dc

voltage output from the pre-integrator charges the integrator for 5ms. The next dc voltage output from the pre-integrator discharges the integrator. When the integrator is completely discharged, the output from the zero detector goes HIGH (+5V) or LOW (0V) depending on the polarity of the integrator output voltage. During the discharge period, a counter on the AI board counts the pulses of a 3.84MHz clock signal. The number of pulses counted represents the ratio of the charge and discharge voltages.

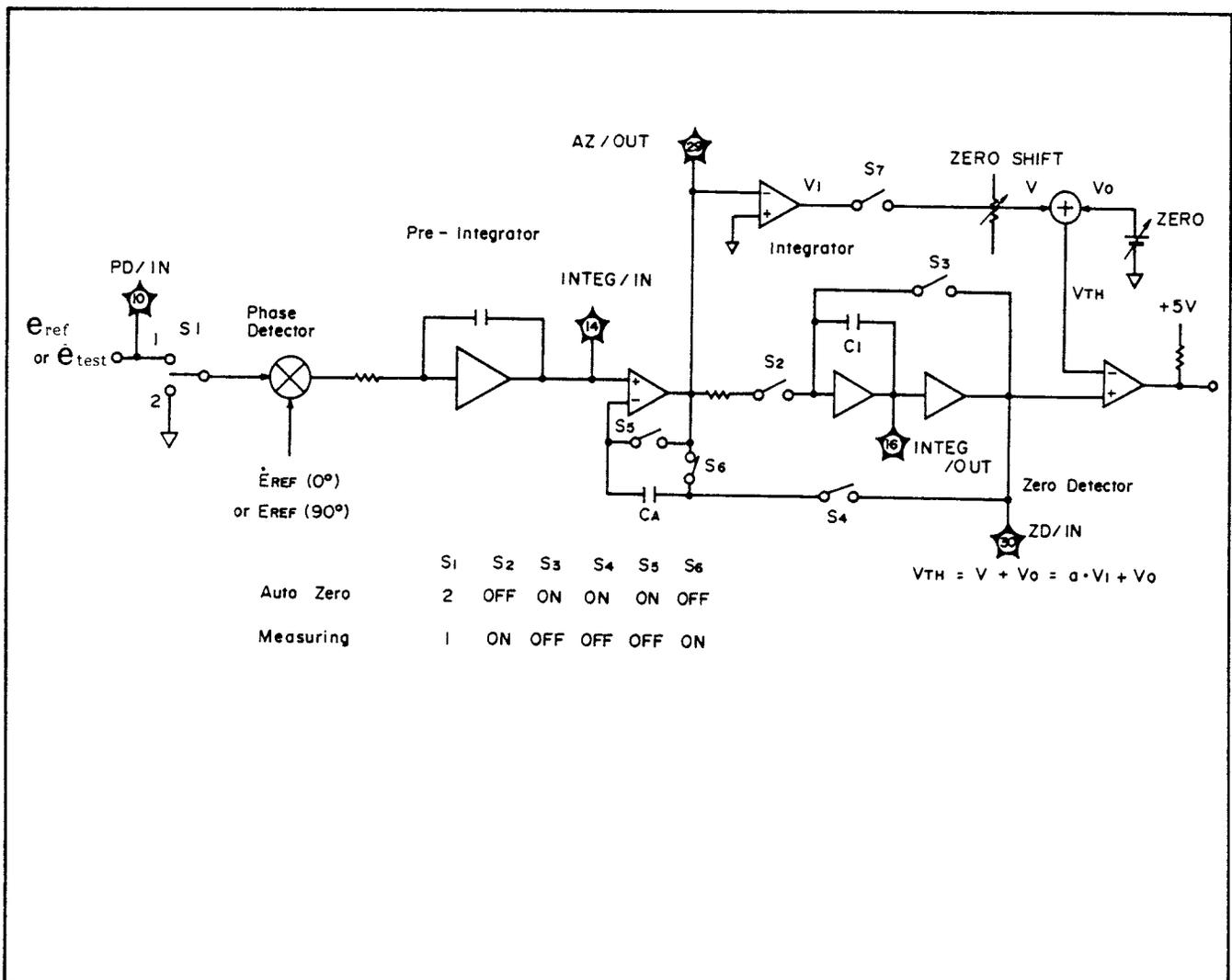


Figure 8-15. Vector Ratio Detector Block Diagram.

Reference Detection Signal (REFDET)

The phase relationship between e_{ref} and the main phase reference signal, X, must be a precise 0° when the real vector components of e_{ref} and e_{test} are measured. When the imaginary vector components of e_{ref} and e_{test} are measured, however, X must be phase shifted 90° in reference to e_{ref} . Refer to Figure A.

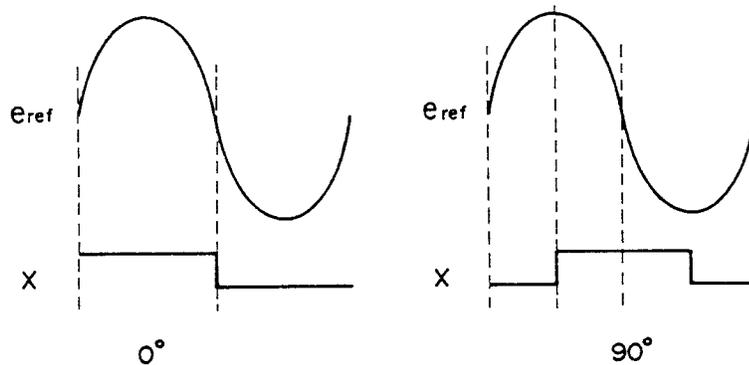


Figure A.

To establish the 0° phase relationship, the instrument detects the negative-to-positive zero crossover of the e_{ref} signal. Refer to Figure B. At the zero crossover, the REFDET signal goes HIGH, starting the 8fclk signal and enabling three shift registers—A2U62, U63, and U64. These shift registers generate the X, Y, and Z phase reference signals shown in Figure C. To shift the X phase reference signal 90° in reference to e_{ref} , the instrument adds two narrow pulses to the 8fclk signal, as shown in Figure D. The phase relationships among X, Y, and Z are constant.

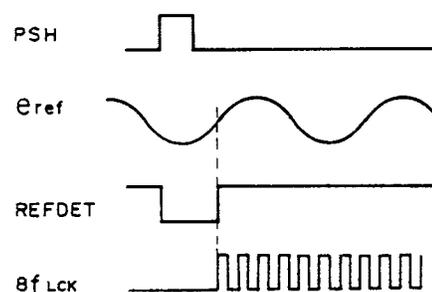


Figure B

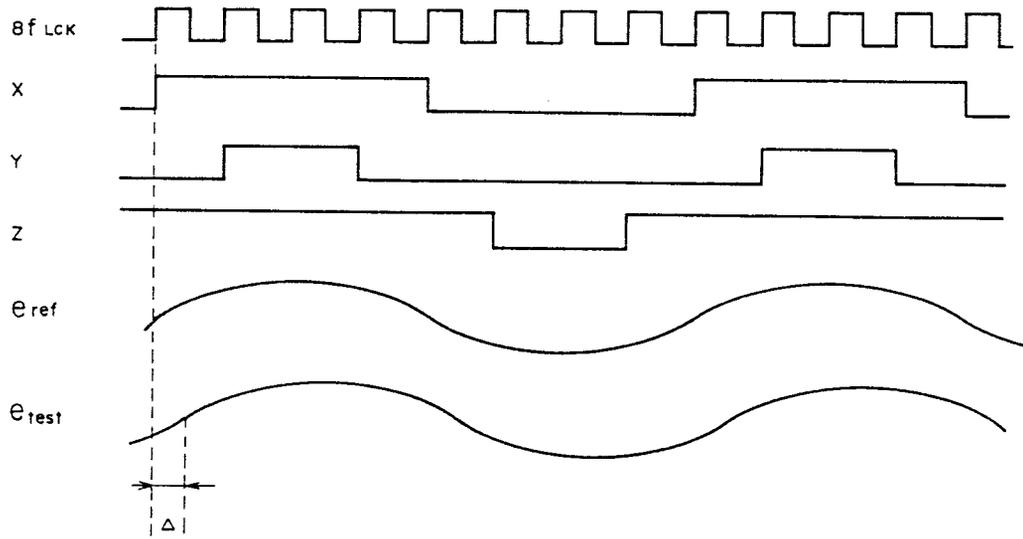


Figure C

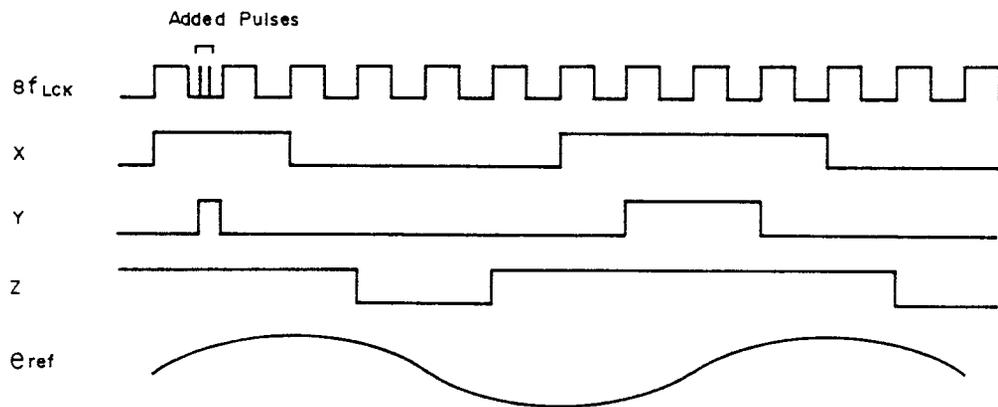


Figure D

Phase Detector

The phase detector is basically an analog switch controlled by a square wave signal. Refer to Figure A. The square wave is the phase reference signal, and it is either in-phase with or 90° out of phase with the e_{ref} signal. When the phase reference signal is HIGH, the signal applied to the INPUT- terminal is selected for output; when the phase reference signal is LOW, the signal applied to the INPUT+ terminal is selected for output. The signals applied to the INPUT+ and INPUT- terminals are e_{ref} (or e_{test}) and an inverted (shifted 180°) e_{ref} (or e_{test}), respectively.

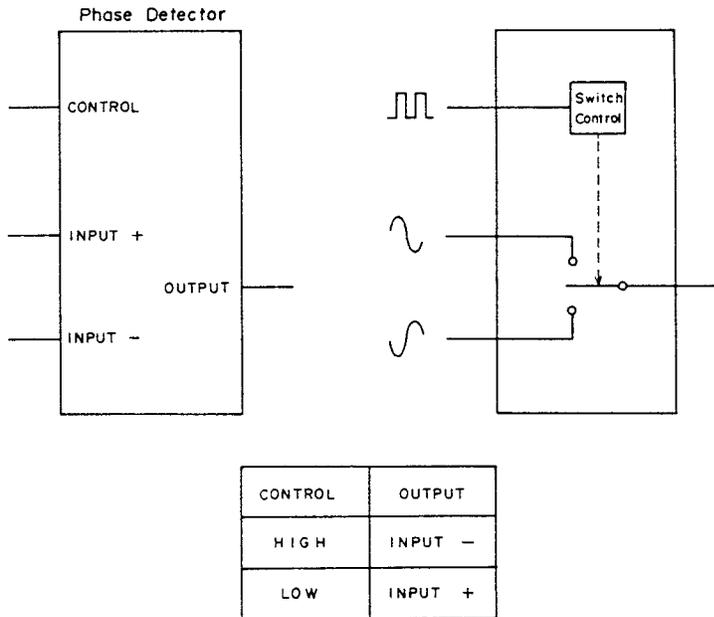


Figure A.

The function of the phase detector is to resolve e_{ref} and e_{test} into their orthogonal (real and imaginary) components. See Figure B.

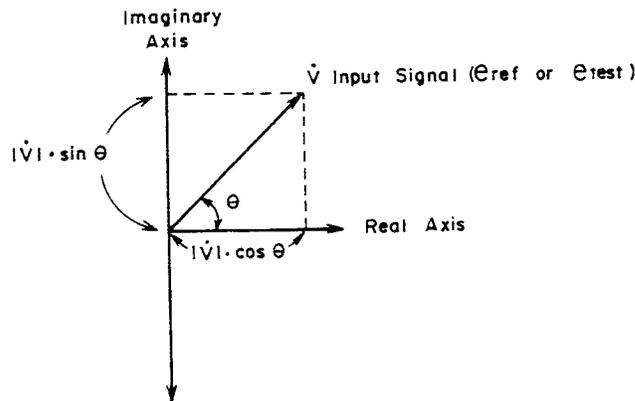


Figure B.

Figure 8-17. Phase Detector (Sheet 1 of 2)

To obtain the real component of e_{ref} or e_{test} , the phase reference signal, which controls switching of the phase detector, must be in-phase with e_{ref} (see Figure C). Similarly, to obtain the imaginary component of e_{ref} or e_{test} , the phase reference signal must be 90° out of phase with e_{ref} (see Figure D).

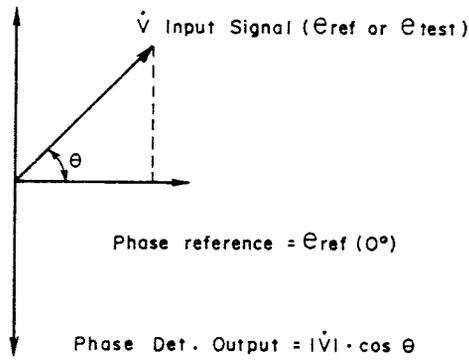


Figure C.

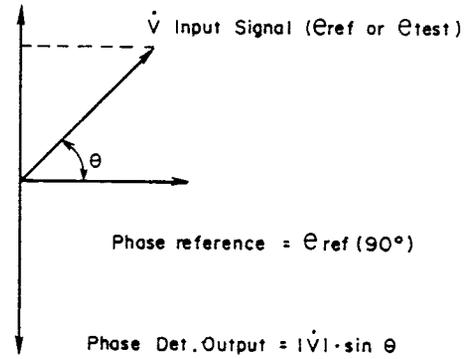


Figure D.

To minimize phase detection errors caused by low order odd harmonics which may be present at the output, three parallel-connected phase detectors (A2U59, U60, and U61) are used in the 4276A, as shown in the simplified circuit schematic of Figure E. Figure F shows the phase reference signals for the three phase detectors.

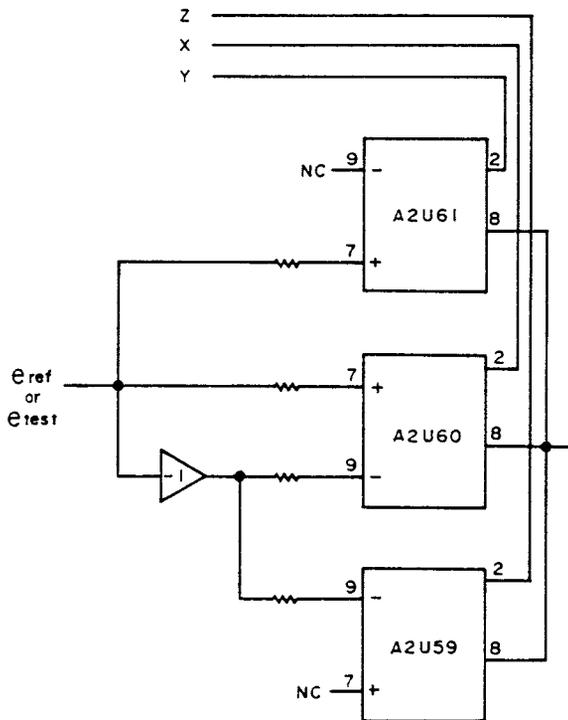


Figure E.

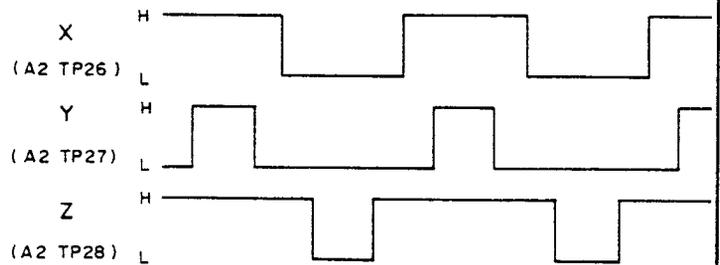


Figure F.

Figure 8-17. Phase Detector (Sheet 2 of 2)

Phase Detection

The phase detector is basically a network of analog switches which are controlled by the square waves shown in Figure A. When the switches are closed, the current through each switch charges the integrator. The integrator output voltage is given as:

$$V_{OUT} = \frac{6a}{CR} \cos \Delta \propto |V_{IN}| \cdot \cos \Delta \quad (\because |V_{IN}| = a)$$

When the control signals X, Y, and Z are phase-shifted by 90 degrees, however, the integrator output voltage is as:

$$V_{OUT} = \frac{6a}{CR} \sin \Delta \propto |V_{IN}| \cdot \sin \Delta$$

$|V_{IN}| \cos \Delta$ and $|V_{IN}| \sin \Delta$ are the in-phase and the 90° out of phase component of the input vector voltage V_{IN} with X, respectively, where X is the phase reference signal.

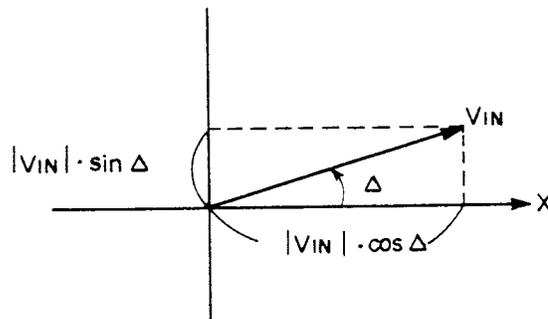
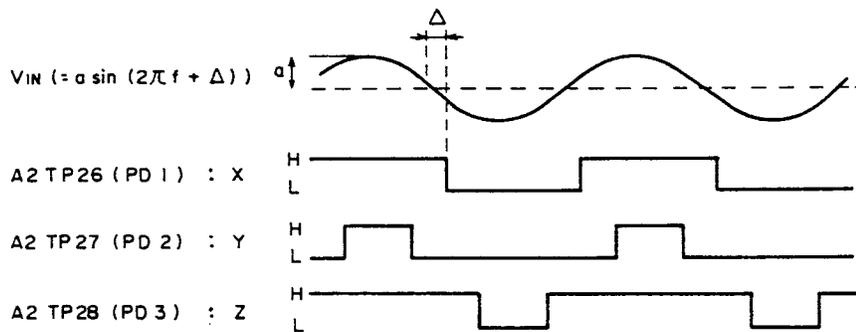
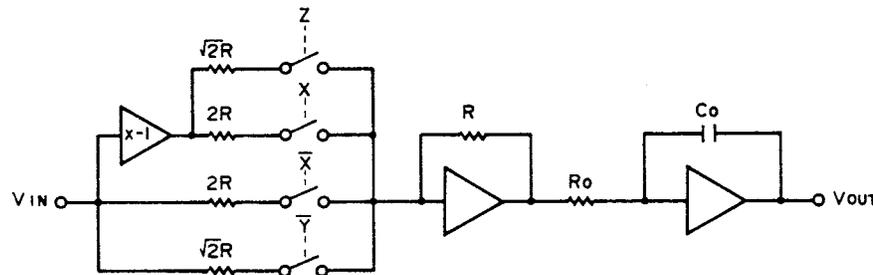


Figure A

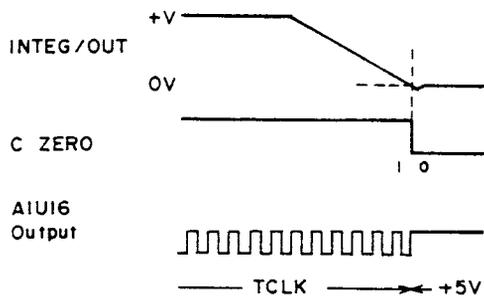
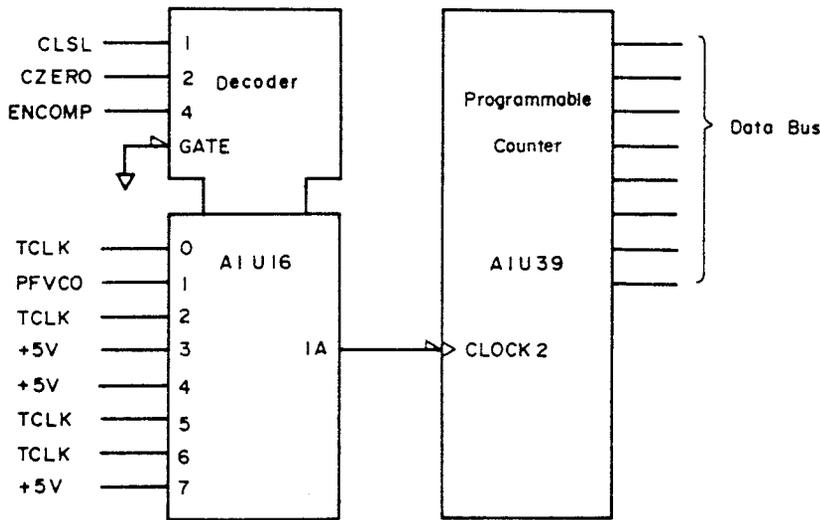
Figure 8-18. Phase Detector (Sheet 2 of 2)

Voltage Ratio Detection

The voltage ratio is easily measured by an integrator and a counter. Refer to Figure A. The integrator is first charged by voltage E_a for a known time, T_0 (determined by the instrument). It is then discharged by voltage E_b . At the start of the discharge cycle, a counter (not shown) is enabled and begins counting the pulses of a reference clock signal. The counter is disabled when the integrator's output reaches 0V. The number of pulses counted by the counter represents the integrator discharge time, T . The voltage ratio E_a/E_b is represented by the following equation:

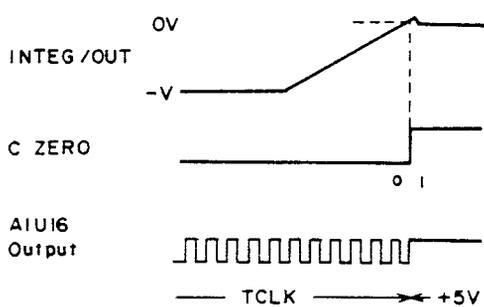
$$E_a/E_b = (1/T_0) \cdot T \quad (\because E_a \cdot T_0 = E_b \cdot T)$$

where T_0 is a known constant.



Downward Discharge

| ENCOMP | CZERO | CLSL | Output |
|--------|-------|------|--------|
| 1 | 1 | 0 | TCLK |
| 1 | 0 | 0 | +5V |



Upward Discharge

| ENCOMP | CZERO | CLSL | Output |
|--------|-------|------|--------|
| 1 | 0 | 1 | TCLK |
| 1 | 1 | 1 | +5V |

Figure A

Figure 8-19. Voltage Ratio Detection.

ZERO SHIFT

The zero reference input to the Zero Detector (A2U68) is slightly shifted from zero volts so as to measure the discharge time of the Integrator (A2U65) accurately even when the discharge time is very short. The additional time required for the zero shift operation, T_{Δ} , is compensated for in the digital section.

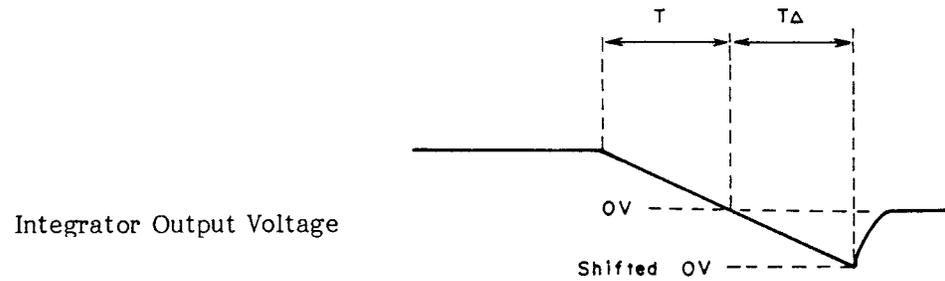


Figure 8-20. ZERO SHIFT.

8-36. DIGITAL SECTION THEORY

8-37. Digital section block diagram is shown in Figure 8-30. A simplified digital section block diagram, including an analog section block diagram, is shown in Figure 8-21.

8-38. Overall instrument operation is controlled by a high speed Z80 microprocessor driven by a 5.76MHz clock. A1U22 controls selection of the required ROM (U5 through U11)

by decoding four address lines--A12 through A15--into seven ROM gate signals--ROMG1 through ROMG7. U11 and ROM gate signal ROMG7 are not used in normal operation. The correspondence between address lines A12 through A15 and ROMs U5 through U10 is given in Table 8-4. Addressing of data stored in the selected ROM is handled by the remaining address lines--A0 through A11. Data read from the selected ROM is sent to the microprocessor via data bus lines D0 through D7. The

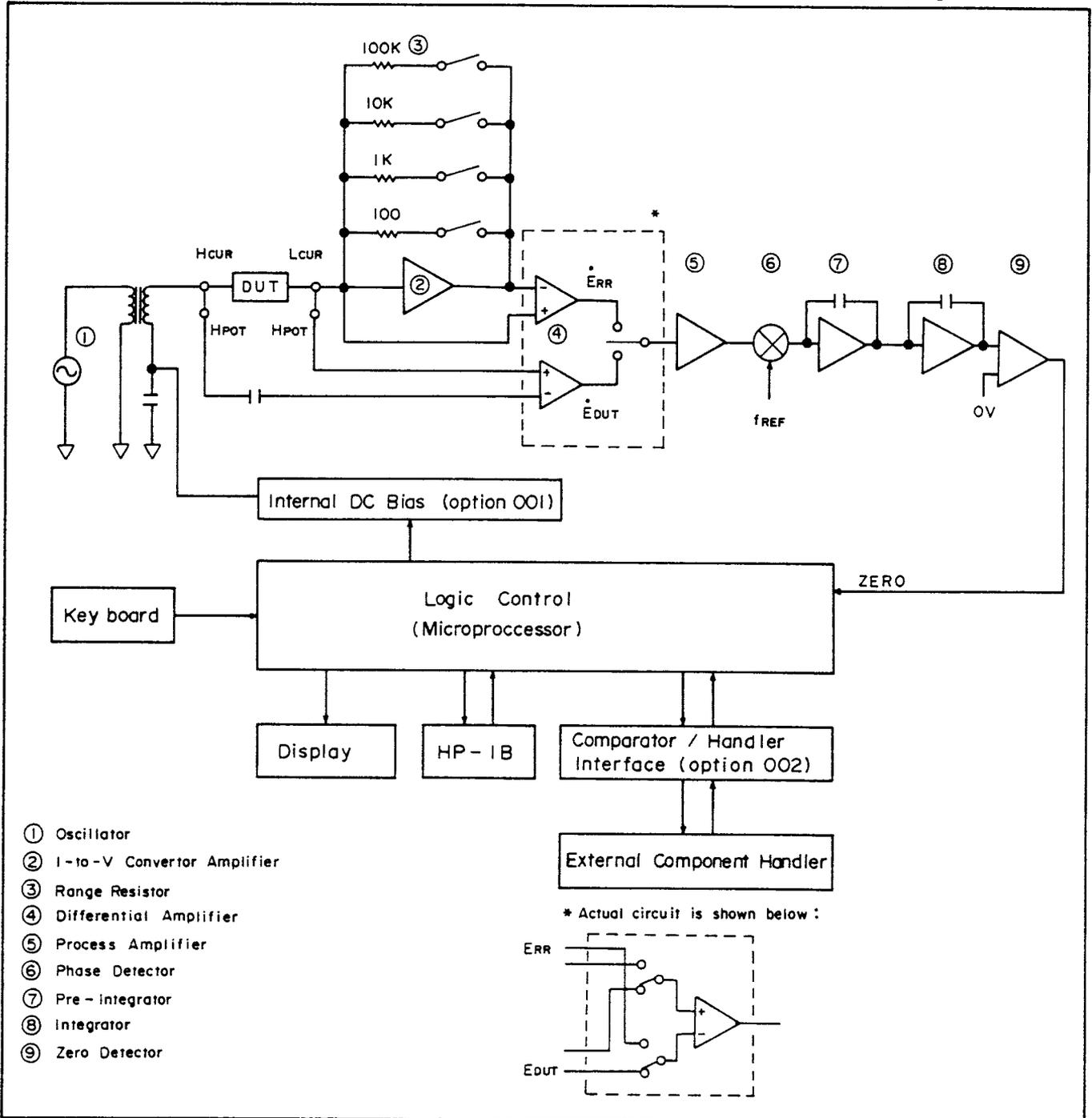


Figure 8-21. Digital Section Block Diagram.

SECTION VIII

microprocessor operates in accordance with the instructions and data stored in the ROMs.

A1U35 provides five signallines—ANACTL1 through ANACTL5--which control the data latches in the analog circuits. Similarly, A1U41 provides six signal lines— $\overline{IOEN0}$ through $\overline{IOEN5}$ --which control data transfer to and from other boards via the data bus. For example, when the $\overline{IOEN0}$ line is LOW, data is transmitted between the microprocessor and the HP-IB circuits on the A21 board. Refer to Table 8- 5 for the correspondence between address lines A3 through A5 and I/O lines $\overline{IOEN0}$ through $\overline{IOEN5}$.

8-39. Operation of the microprocessor is interrupted by any one of three interrupt signals: IBINT, TRIGINT and KEYINT. The IBINT line is active (LOW) when an interrupt request is on theHP-IB; TRIGINT is active (LOW) when the instrument is externally triggered; KEYINT is active (HIGH) when a key on the front panel is pressed. These interrupts are detected at the beginning of a measurement cycle or before each voltage-ratio measurement period.

8-40. The microprocessor, the HP-IB circuits on the A21 board, and the data latches on the A22 board (option 001) are reset each time the RESET signal goes LOW. RESET goes LOW if the +5V supply on the A1 board drops below +4.8V. Refer to Figure 8- 22. The active (LOW) time for the RESET signal is approximately 500ms.

8-41. Perhaps the most important function of the section is to measure the time required for the main integrator on the A2 board to discharge during each voltage-ratio measurement. This is done by a counter, A1U39. At the start of the integrator discharge period, A1U39 is enabled and begins counting the pulses of a 3.84MHz clock signal (TCLK) output from A1U16. When the integrator is completely discharged (output reaches zero volts), the ZERO DETECTOR on

the A2 board sends the ZERO signal, which stops the clock. The time required for the integrator to discharge is indicated by the number in A1U39. See Figures 8- 19 and 8- 20.

8-42. The A1 board contains an 11.5200MHz crystal oscillator, A1U1. Output from the oscillator is counted down to provide the 5.76MHz clock signal for the microprocessor, the 3.84MHz clock signal for voltage-ratio measurement, and the 8kHz reference signal for the phase-locked loop on the A2 board.

8-43. Figure 8-23 shows the flow diagram for the measurement sequence.

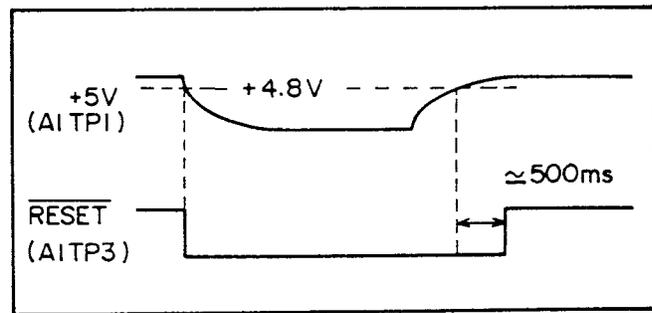


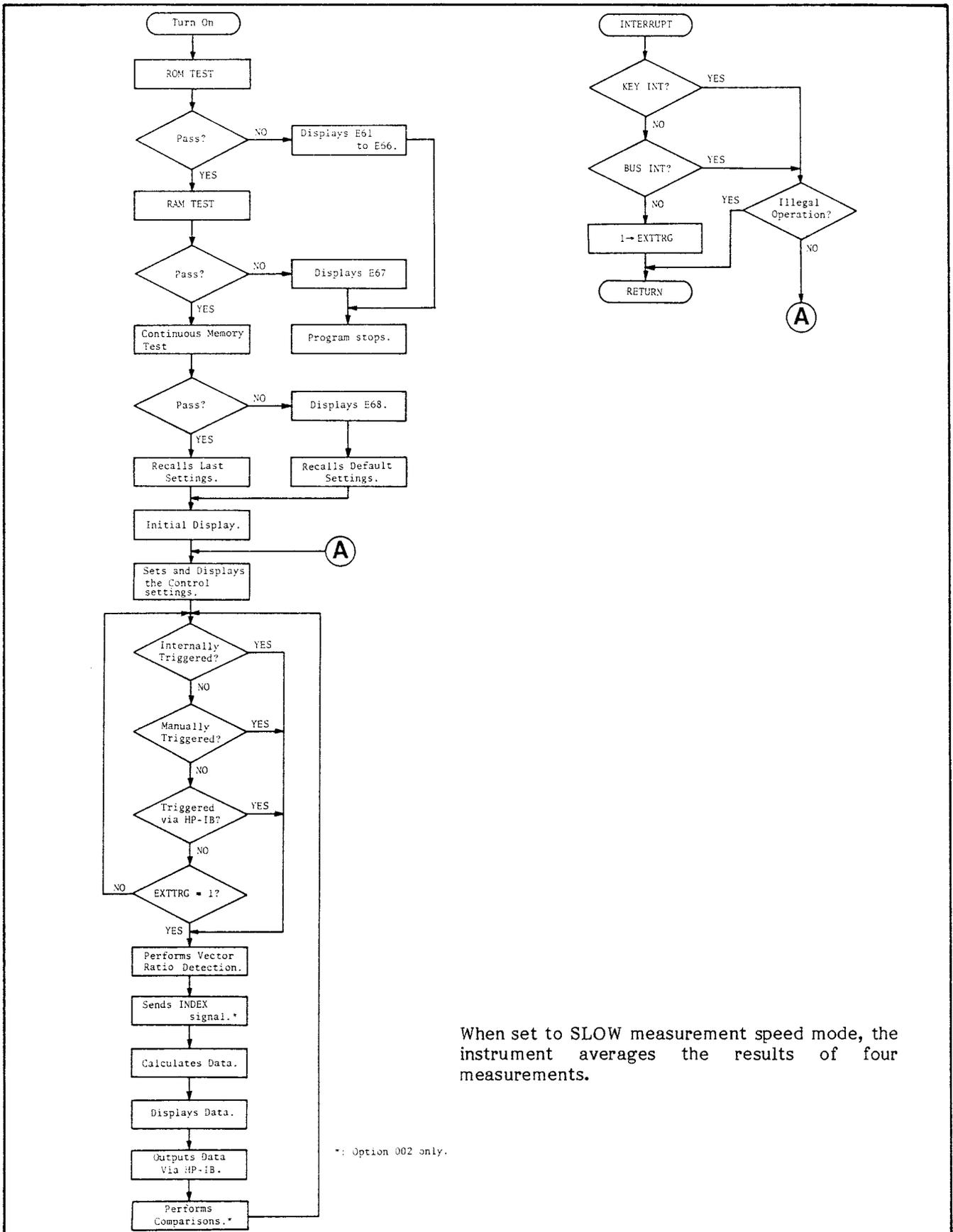
Figure 8-22 . Reset Signal.

Table 8- 5 . I/O Enable Signals

| Address Lines | | | I/O Enable Signal |
|---------------|---|---|--------------------|
| 5 | 4 | 3 | |
| 0 | 0 | 0 | $\overline{IOEN0}$ |
| 0 | 0 | 1 | $\overline{IOEN1}$ |
| 0 | 1 | 0 | $\overline{IOEN2}$ |
| 0 | 1 | 1 | $\overline{IOEN3}$ |
| 1 | 0 | 0 | $\overline{IOEN4}$ |
| 1 | 0 | 1 | $\overline{IOEN5}$ |

Table 8- 4 . ROM Addresses

| Address Lines | | | | | | | | | | | | | | Addressed ROM | | |
|---------------|----|----|----|----|----|---|---|---|---|---|---|---|---|---------------|---|--------------|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | | 1 | 0 |
| 0 | 0 | 0 | 0 | - | - | - | - | - | - | - | - | - | - | - | - | ROM0 (A1U5) |
| 0 | 0 | 0 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | ROM1 (A1U6) |
| 0 | 0 | 1 | 0 | - | - | - | - | - | - | - | - | - | - | - | - | ROM2 (A1U7) |
| 0 | 0 | 1 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | ROM3 (A1U8) |
| 0 | 1 | 0 | 0 | - | - | - | - | - | - | - | - | - | - | - | - | ROM4 (A1U9) |
| 0 | 1 | 0 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | ROM5 (A1U10) |



When set to SLOW measurement speed mode, the instrument averages the results of four measurements.

*: Option 002 only.

Figure 8-23. Flow Diagram.

SECTION VIII

8-44. OPTIONS

8-45. The theory of operation for the 4276A's optional circuits is outlined in the following paragraphs.

8-46. OPTION 001 INTERNAL DC BIAS (A22)

8-47. The A22 board primarily contains a DAC (A22U3) and an output amplifier, as shown in Figure 8-24. The DAC outputs a dc voltage whose polarity and magnitude are determined by the reference voltage, V_{ref} , and the digital is determined by the digital data sent from the microprocessor and stored in latches U1 and U2. Output voltage is calculated as follows:

$$V_{OUT} = -V_{ref} \cdot \sum_{n=1}^{10} B_n \cdot 2^{-n}$$

(B_n : 0 or 1)

where V_{ref} is determined as follows:

| Internal DC Bias Voltage Range | V_{ref} |
|--------------------------------|-----------|
| 40.0V to .00V | -6.3V |
| -.01V to -40.0V | +6.3V |

The output voltage of DAC is shown in Figure A.

V_{ref} is switched by an analog switch controlled by Data Bus lines BD6 and BD7 via the latch A22U2. The two latches, A22U1 and U2, are successively enabled by clock signals $\overline{IOEN1}$ and $\overline{IOEN2}$ to output digital data to the DAC and to control the analog switches. Another analog switch selects the attenuation factor — x1 or x1/5 — in accordance with the internal dc bias voltage setting as follows:

| Internal DC Bias Voltage Range | Attenuator |
|--------------------------------|------------|
| $\pm(.00V \text{ to } 9.99V)$ | x 1/5 |
| $\pm(10.0V \text{ to } 40.0V)$ | x 1 |

The DAC output voltage shown in Figure A is attenuated by a x1 or x1/5 attenuator to obtain the linear characteristic shown in Figure B. This attenuated voltage is amplified by the x8 output amplifier.

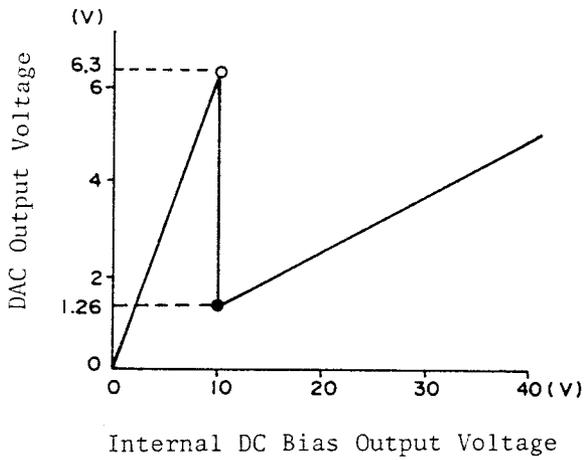


Figure A

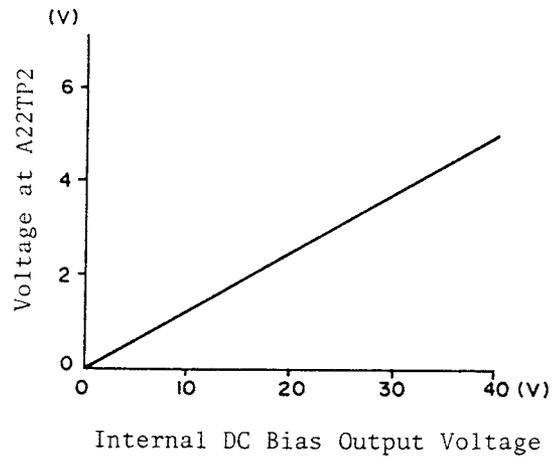


Figure B

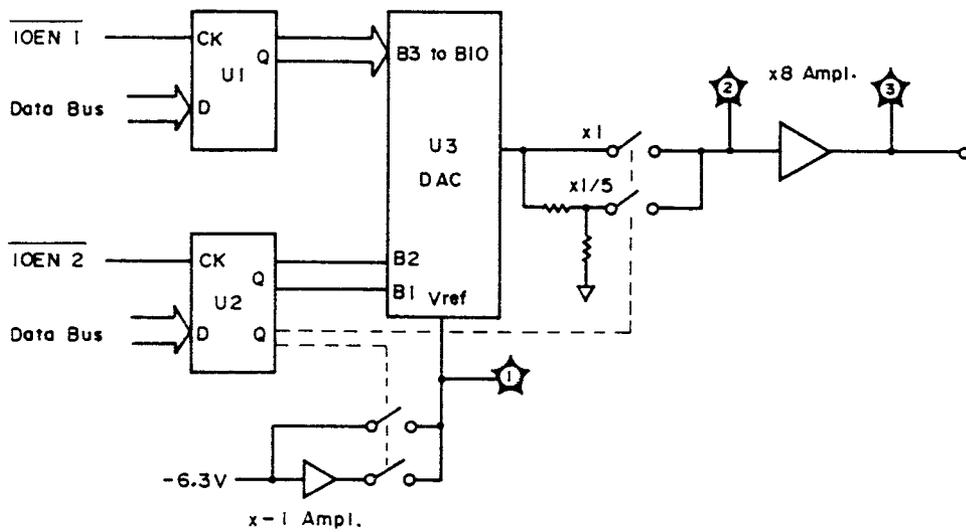


Figure 8-24. A22 Board Block Diagram.

8- 48. TIMING DIAGRAM DISCUSSION

8-49. Figure 8- 26 shows the timing diagram for the various signals necessary for VRD operation. In the figure, the REFDET signal goes HIGH when the e_{ref} signal crosses zero volts in a negative voltage-to-positive voltage direction after the PSH signal goes LOW. The REFDET signal provides the start timing for the $8F$, which is the source of the phase reference signals used by the phase detector. Refer to Figure 8- 25.

Table 8- 7 . Pre-Integrator Charge Time

| Test Frequency | Measurement Speed | |
|----------------|-------------------|---------|
| | MED, SLOW | FAST |
| 100Hz to 199Hz | 1/f [s] | 1/f [s] |
| 200Hz to 498Hz | 5ms | |
| 500Hz to 20kHz | | |

f: Test Frequency

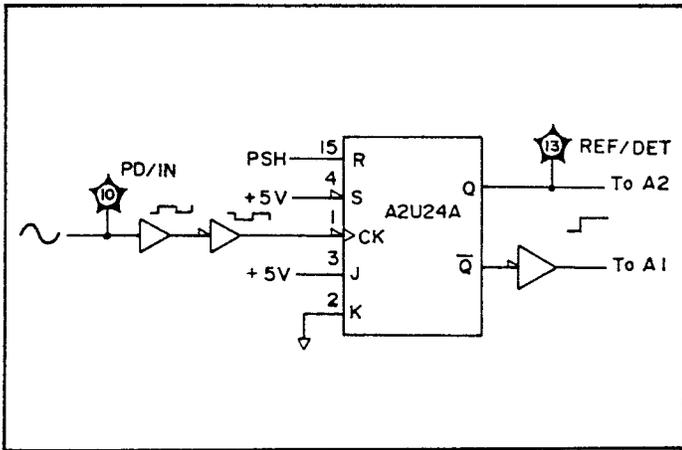


Figure 8- 25. REFDET Circuit.

Note

On the ranges shown in the table below, pre-integrator charge time, T_1 , is 10 times longer than those listed in Table 8- 7 .

8- 50. In each voltage ratio detection period — , , and — the integrator charge time, T_0 , is constant for the selected measurement speed, as listed in Table 8- 6 .

| C Range | Test Frequency | | | |
|---------|----------------|-------|------|-------|
| | 100Hz | 200Hz | 2kHz | 20kHz |
| 10mF | | | | |
| 1mF | | | | |
| 100µF | | | | |
| 10µF | | | | |
| 1µF | | | | |
| 100nF | | | | |
| 10nF | | | | |
| 1nF | | | | |
| 100pF | | | | |
| 10pF | | | | |

Capacitance Measurement

Table 8- 6 . Integrator Charge Time

| Measurement Speed | To |
|-------------------|--------|
| MED, SLOW | 5ms |
| FAST | 1.25ms |

8- 52. For the reference convenience, abbreviated signal names are listed in Table 8- 8 .

The discharge times T_α , T_β , and T_γ are measured by a programmable counter, AlU39, which counts the pulses of a 3.84MHz clock signal.

Table 8- 8 . Signal Abbreviations

| Abbreviation | Description |
|---------------|---------------------------|
| PSH | Phase Search |
| PS1, PS2, PS3 | Phase Signals 1 through 3 |
| REFDET | Reference Detection |
| AZT | Auto Zero Time |
| PC | Polarity Check |
| ZST | Zero Shift |
| IRST | Integrator Reset |
| PRST | Pre-Integrator Reset |
| IOFF | Integration Off |
| IOFS | Integration Off Switch |

8- 51. For accurate dual-slope analog-to-digital conversion, the VRD contains a pre-integrator which converts the phase detector's output signal into a dc voltage for integration by the main integrator. The pre-integrator charge time, T_1 , depends on the test frequency and the measurement speed. Refer to Table 8- 7 .

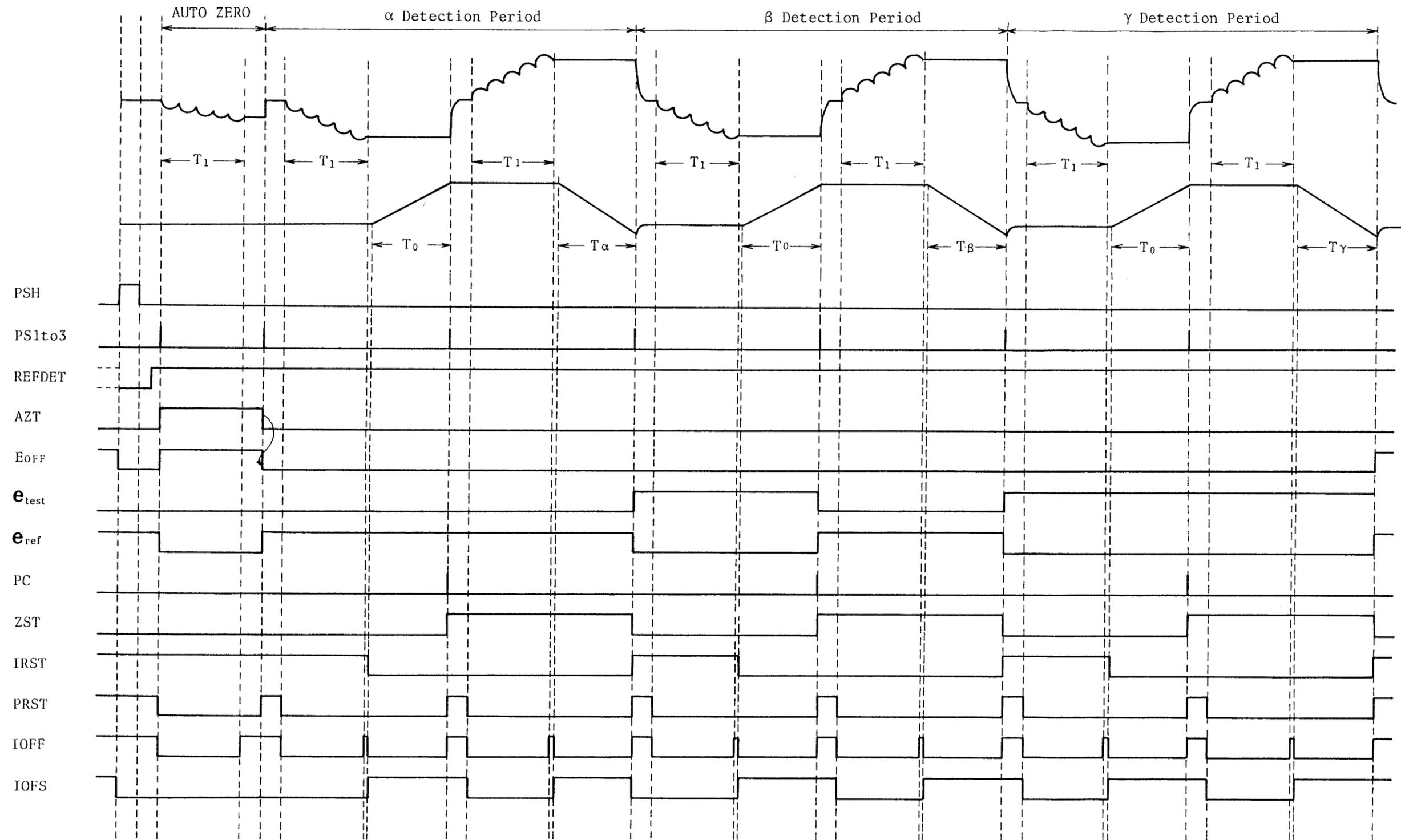


Figure 8-26. Timing Diagram.

SECTION VIII

8-53. Repair.

8-54. Board assembly locations are shown in Figure 8-27. Graphic symbols and abbreviated signal names used in schematic diagrams are explained in Figure 8-28 and Table 8-9, respectively.

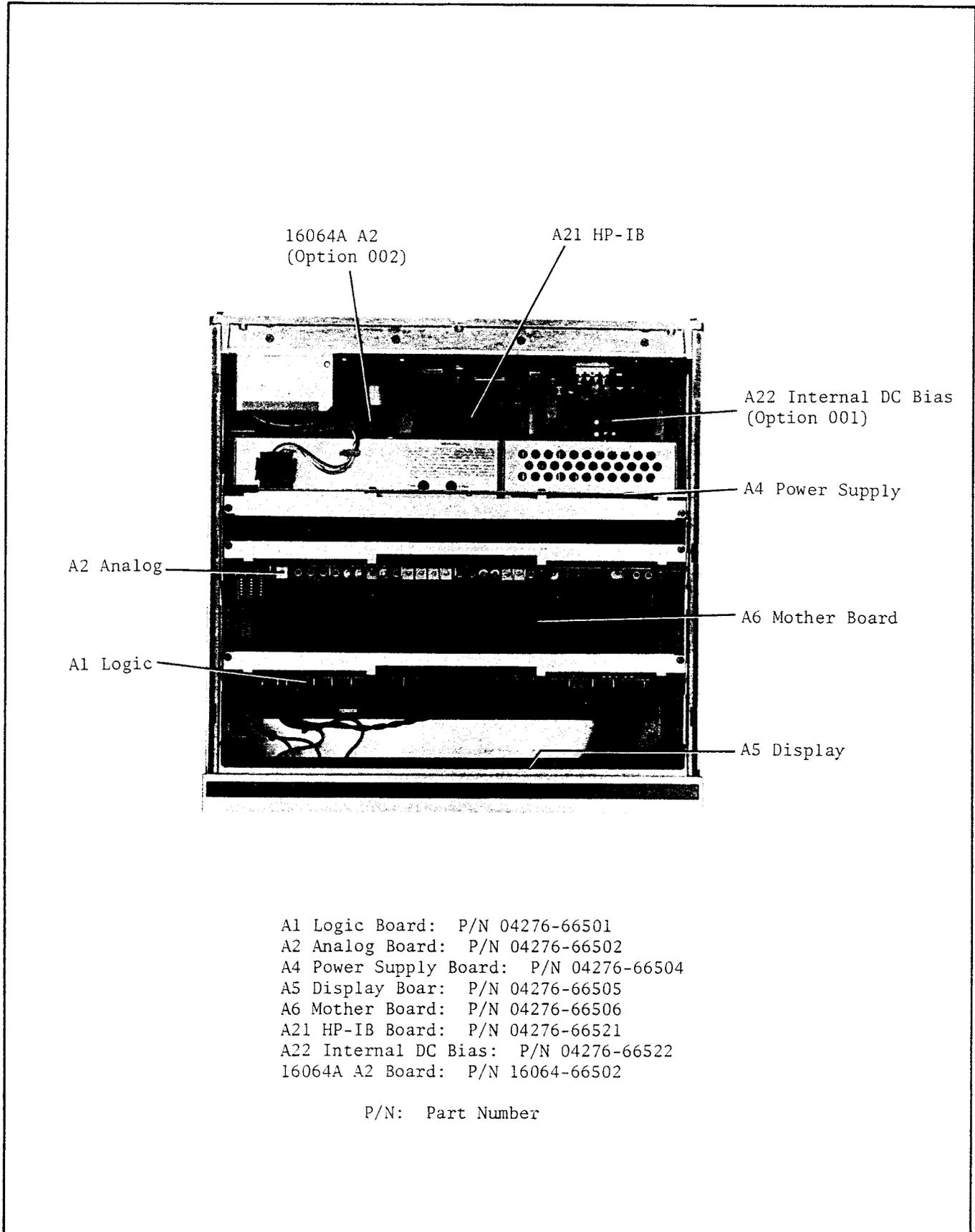


Figure 8- 27. Assembly Locations (Top View).

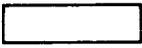
| | |
|---|--|
| P/O | Part of. |
|  | Knob control. |
|  | Screwdriver adjustment. |
|  | Circuit assembly boarderline. |
| * | Asterisk denotes a factory selected value. Value shown is typical, part may be omitted. |
|  | Bead inductance. |
|  | Circuit board pattern inductance. |
|  | Heavy line indicates main signal path. |
|  | Heavy dashed line indicates main feedback path. |
|  | Wiper moves towards CW with clockwise rotation of control (as viewed from shaft or knob). |
|  | Numbered test point. Measurement aid provided. |
|  | Denotes wire color code. Code used is the same as the resistor color code (e.g., 9.4.7 denotes white/yellow/violet). |
|  | Encloses front panel designations. |
|  | Shielded area. |
|  | Indicates direct conducting connection to earth. |
|  | Indicates conducting connection to chassis or frame. |
|  | Indicates circuit common connection. |

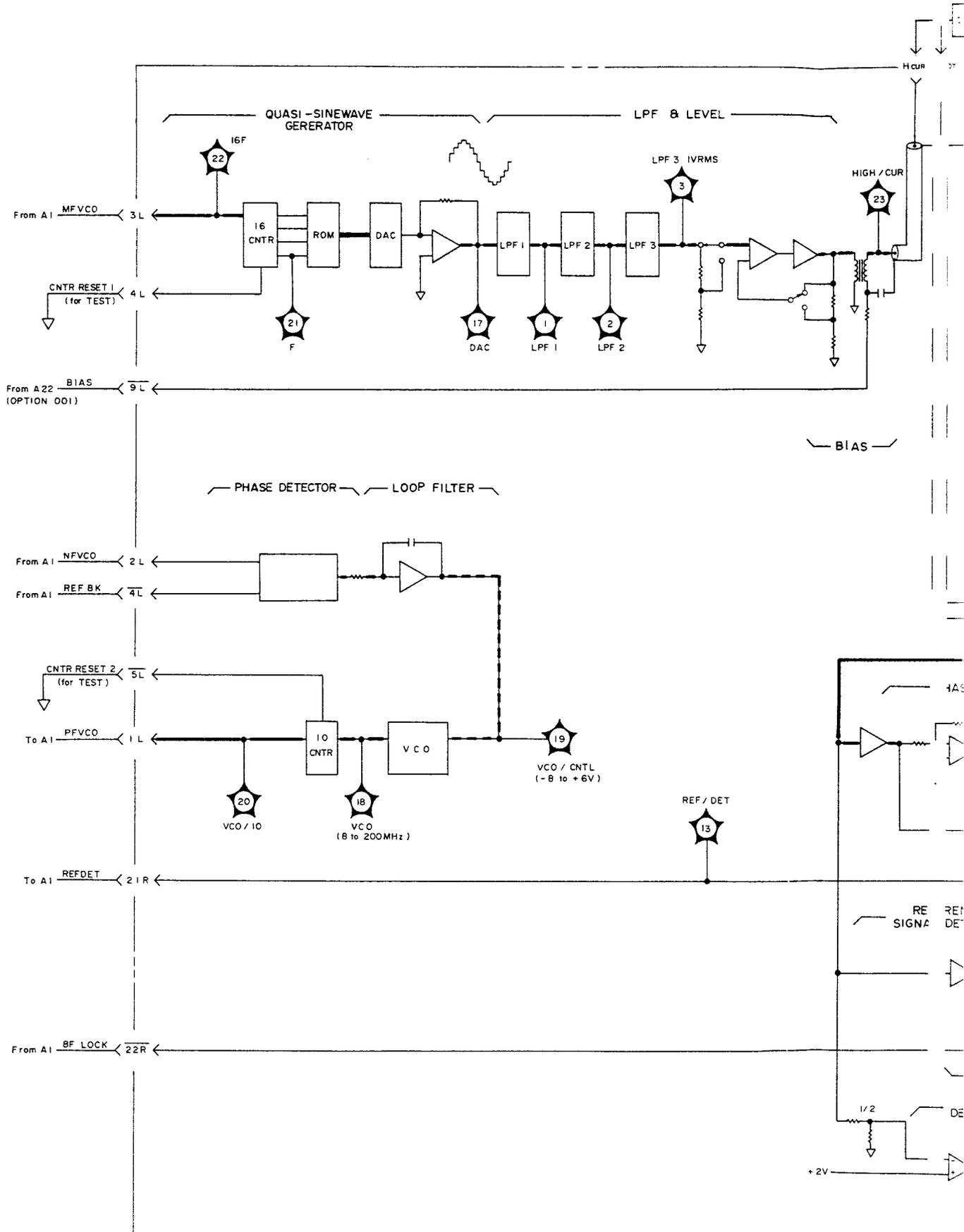
Figure 8-28. Schematic Diagram Notes.

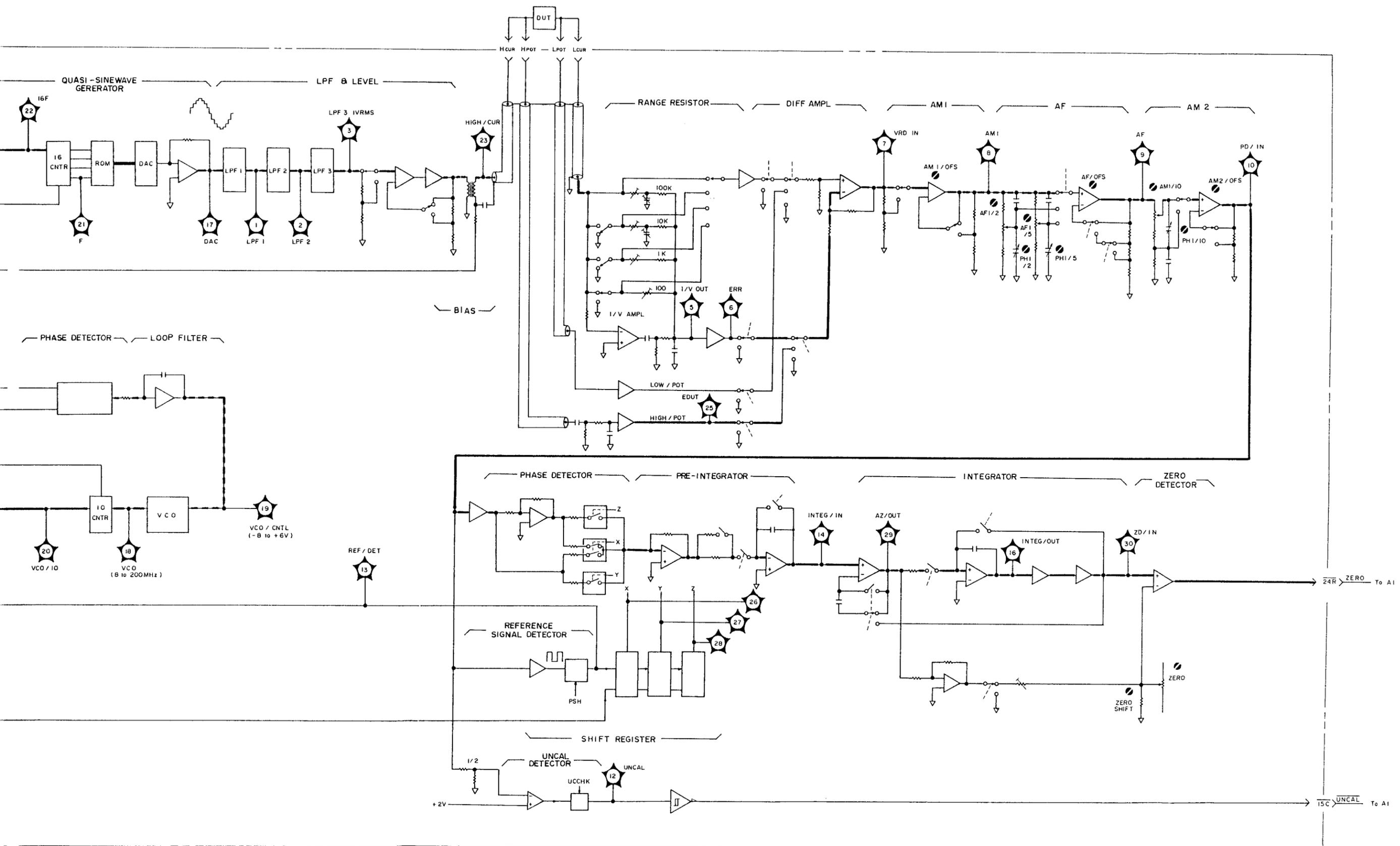
Table 8 9 . Mnemonic Information (Sheet 1 of 2)

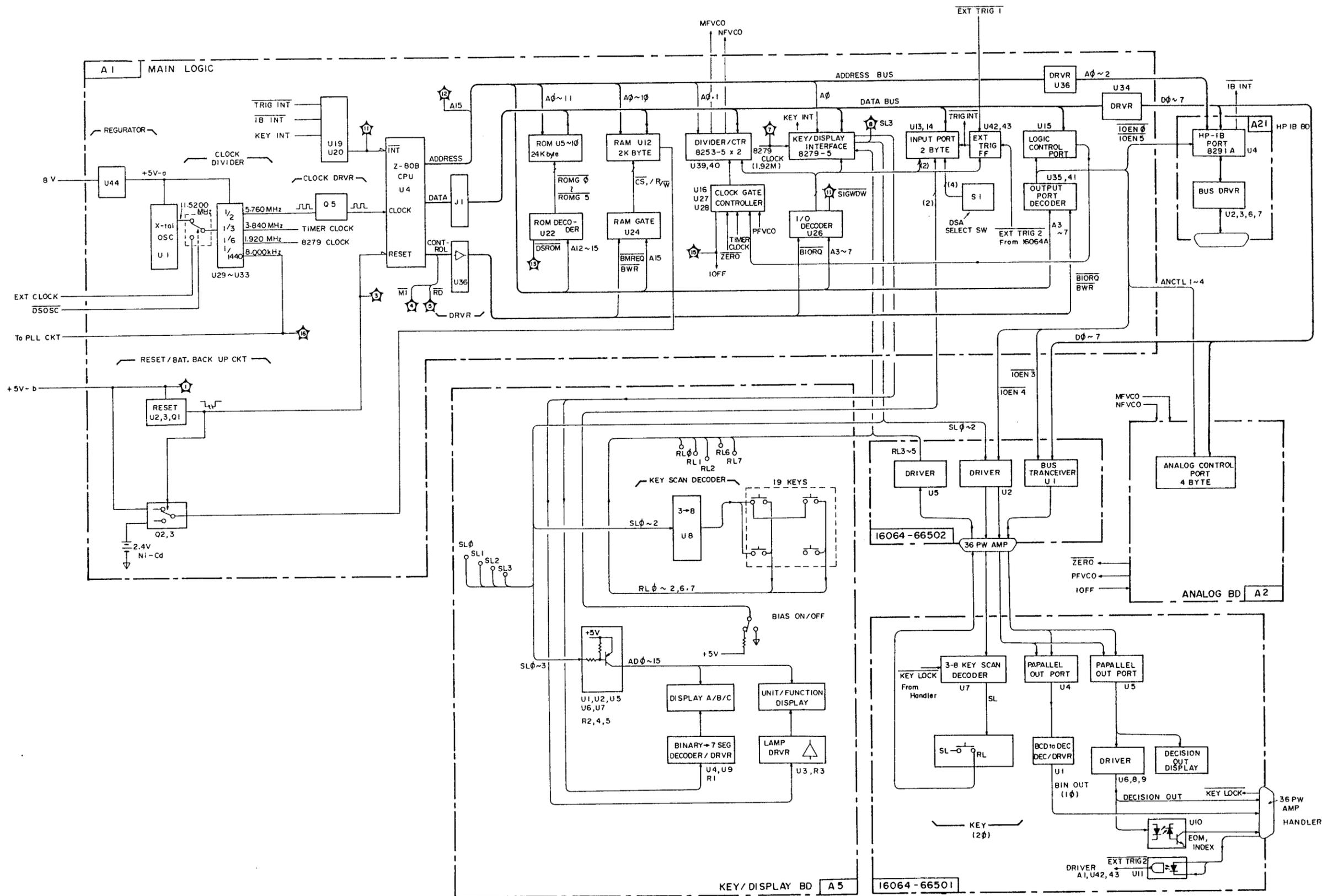
| Mnemonic | DESCRIPTION |
|-----------------------------------|--|
| AF | Amplifier-Frequency |
| AM1 | Amplifier-Magnitude 1 |
| AM2 | Amplifier-Magnitude 2 |
| $\overline{\text{ANACTL 1 - 5}}$ | Analog section control lines |
| BA0-2 | Buffered address bus lines to the A21 HP-IB board |
| BATTERY | Continuous Memory battery supply and charge line |
| BCLK | Buffered master clock (5.760MHz) |
| BDO-7 | Buffered data bus lines |
| $\overline{\text{BEXT TRIG 2}}$ | Buffered external trigger signal from the 16064A |
| BIAS | Output from the internal dc bias source (0 to $\pm 40\text{V}$) |
| BIASG | Internal dc bias source common |
| $\overline{\text{BIAS}}$ | A22 DC BIAS board is installed. |
| $\overline{\text{BIAS ON}}$ | Front panel DC BIAS switch status |
| $\overline{\text{BIN1 - 9}}$ | Comparison results output to an external component handler |
| $\overline{\text{BIOENS 3 - 4}}$ | Buffered I/O enable lines from the 16064A A2 board to the A1 board. |
| $\overline{\text{BIORD}}$ | Buffered I/O read line from the 16064A A2 board to the A1 board. |
| $\overline{\text{BIOWR}}$ | Buffered I/O write line from the 16064A A2 board to the A1 board. |
| BLANK | Display blanking signal |
| BRL3-5 | Buffered return line from the 16064A keyboard |
| BSLO- 2 | Buffered send line to the 16064A keyboard |
| $\overline{\text{CPWT}}$ | Comparator wait signal |
| DA 0 - 3 | Front panel display data lines |
| DB 0 - 3 | Front panel display data lines |
| $\overline{\text{DQ HI, IN, LO}}$ | Comparison results output to an external component handler. |
| DUT | Device under test |
| $\overline{\text{EOM}}$ | End of measurement. Informs an external component handler that the comparison has been made. |
| EXT DCV1 | External DC supply input to HANDLER INTERFACE for open collector outputs. |
| EXT DCV2 | External DC supply. Input from an external component handler. |
| EXT DCV2 COM | EXT DCV2 return line to an external component handler. |
| EXT TRIG | External trigger input from an external component handler. |
| EXT TRIG 1 | External trigger signal from the rear panel. |
| EXT TRIG 2 | External trigger signal from 16064A. |
| Hc | Center conductor of high current terminal |

Table 8- 9 . Mnemonic Information (Sheet 2 of 2)

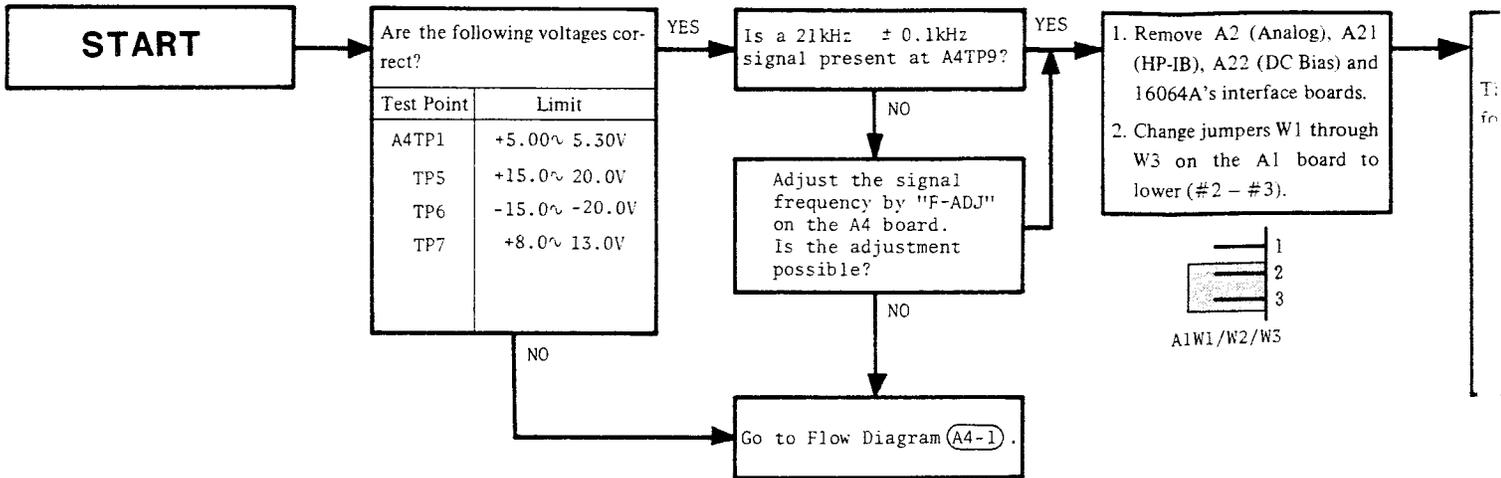
| Mnemonic | DESCRIPTION |
|---|---|
| Hcg | Outer conductor of high current terminal |
| Hp | Center conductor of high potential terminal |
| $\overline{\text{IB INT}}$ | HP-IB interrupt |
| $\overline{\text{INDEX}}$ | Signal which informs an external component handler that the instrument has finished analog measurement. |
| $\overline{\text{IOEN0}} - \overline{5}$ | I/O enable lines |
| IOFF | Integrator off |
| $\overline{\text{IORD}}$ | I/O read |
| $\overline{\text{IOWR}}$ | I/O write |
| KEY LOCK | 16064A keyboard disable. Input from an external component handler. |
| Lc | Center conductor of low current terminal |
| Lcg | Outer conductor of low current terminal |
| $\overline{\text{LC HI}}, \overline{\text{IN}}, \overline{\text{LO}}$ | Comparison results output to an external component handler |
| Lp | Center conductor of low potential terminal |
| MF VCO | Divided VCO output (16 times the test frequency) |
| NF VCO | Divided VCO output (8kHz) |
| $\overline{\text{OUT OF BIN}}$ | Comparison result output to an external component handler |
| PD | Phase detector |
| PF VCO | Divided VCO output ($f_{\text{vco}} \div 10$) |
| PWF | Power failure |
| $\overline{\text{REF DET}}$ | Reference phase detect |
| $\overline{\text{REF8K}}$ | VCO reference frequency, 8kHz |
| $\overline{\text{RESET}}$ | Reset signal for A21 HP-IB and A22 DC BIAS boards |
| RL0 - 2, 6-7 | Return lines from the A5 DISPLAY board. |
| SL0 - 3 | Send lines to the A5 DISPLAY board. |
| $\overline{\text{UNCAL}}$ | Uncalibration detect |
| ZERO | Integrator zero detect |
| 8FLCK | Signal for phase detector (8 times of test frequency) |



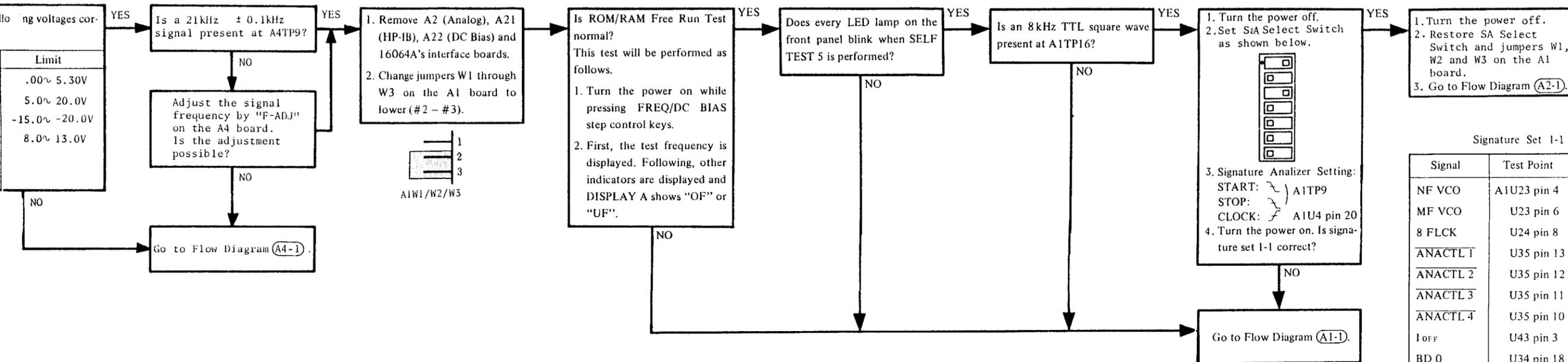




Board Isolation Flow Diagram



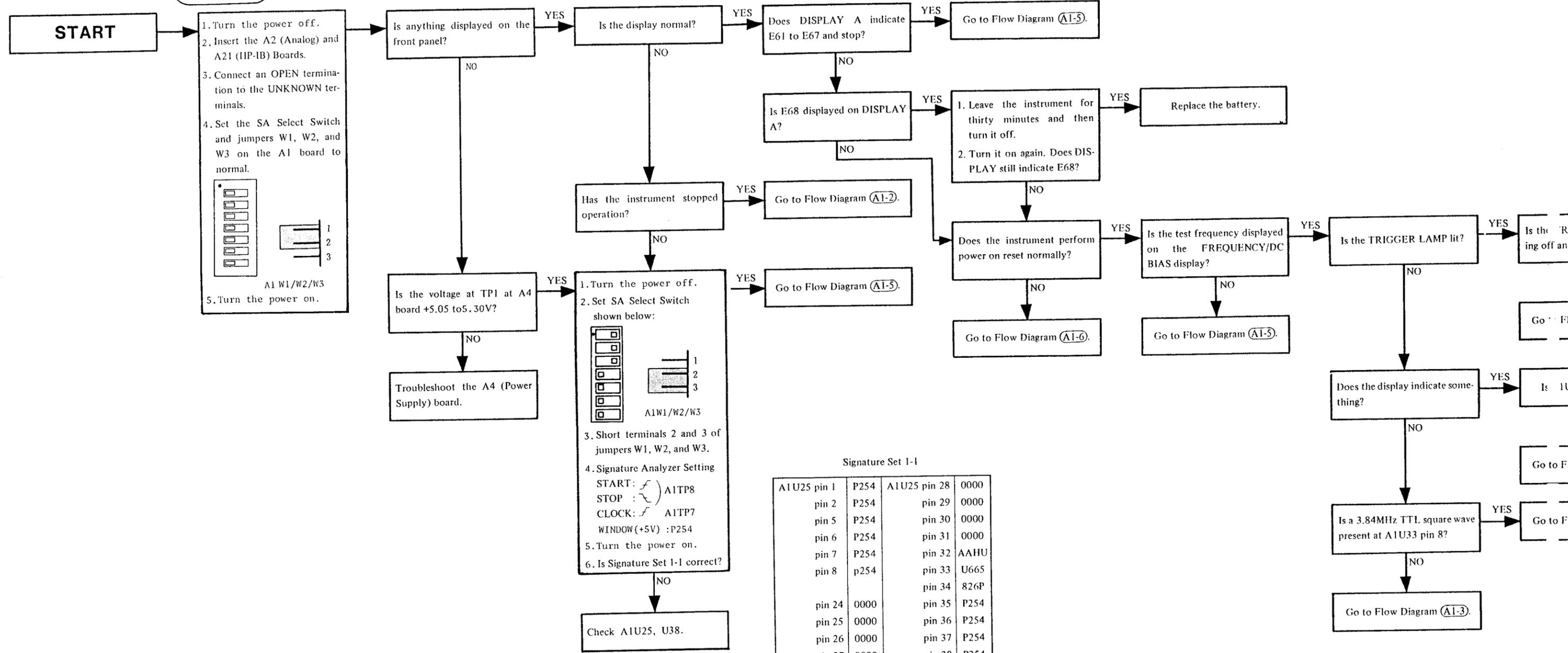
Diagram



Signature Set 1-1

| Signal | Test Point | Signature |
|----------|-------------|-----------|
| NF VCO | A1U23 pin 4 | CF47 |
| MF VCO | U23 pin 6 | F3C8 |
| 8 FLCK | U24 pin 8 | 7F1U |
| ANACTL 1 | U35 pin 13 | 84U4 |
| ANACTL 2 | U35 pin 12 | P4P5 |
| ANACTL 3 | U35 pin 11 | 7FP4 |
| ANACTL 4 | U35 pin 10 | 44A6 |
| I OFF | U43 pin 3 | 4625 |
| BD 0 | U34 pin 18 | 6UAC |
| BD 1 | U34 pin 17 | 2P3P |
| BD 2 | U34 pin 16 | 708A |
| BD 3 | U34 pin 15 | 05PF |
| BD 4 | U34 pin 14 | 491U |
| BD 5 | U34 pin 13 | 239P |
| BD 6 | U34 pin 12 | F019 |
| BD 7 | U34 pin 11 | H19P |
| IOEN 0 | U41 pin 15 | C65F |
| IOEN 1 | U41 pin 14 | 195C |
| IOEN 2 | U41 pin 13 | PPA0 |
| IOEN 3 | U41 pin 12 | 955H |
| IOEN 4 | U41 pin 11 | A8A3 |
| IOEN 5 | U41 pin 10 | C923 |

Flow Diagram A1 - 1



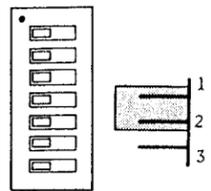
Signature Set 1-1

| | | | |
|-------------|------|--------------|------|
| A1U25 pin 1 | P254 | A1U25 pin 28 | 0000 |
| pin 2 | P254 | pin 29 | 0000 |
| pin 5 | P254 | pin 30 | 0000 |
| pin 6 | P254 | pin 31 | 0000 |
| pin 7 | P254 | pin 32 | AAHU |
| pin 8 | p254 | pin 33 | U665 |
| | | pin 34 | 826P |
| pin 24 | 0000 | pin 35 | P254 |
| pin 25 | 0000 | pin 36 | P254 |
| pin 26 | 0000 | pin 37 | P254 |
| pin 27 | 0000 | pin 38 | P254 |
| | | pin 39 | P254 |

Flow Diagram **A1 - 2**

START

1. Turn the power off.
 2. Set SA Select Switch and jumpers W1, W2 and W3 to normal.
 3. Turn the power on.



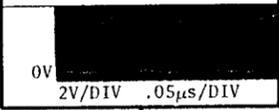
Is the voltage of A1U4 pin 11 +5V?

NO
 Check +5-b line.

YES
 Is the voltage of A1U1 pin 14 +5V?

NO
 Check A1U44 and +5V-a line.

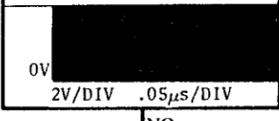
YES
 Is a 5Vp-p 5.76 MHz square wave (see photo) present at A1U4 pin 6.



NO
 Is a 11.52 MHz TTL square wave present at A1U17 pin 6?

YES
 Are the following TTL signals correct?

NO
 Is the signal shown below present at A1U1 pin 8?



NO
 Check A1U1.

YES
 Is an 8 kHz TTL square wave present at A1TP16?

NO
 Go to Flow Diagram A1-3

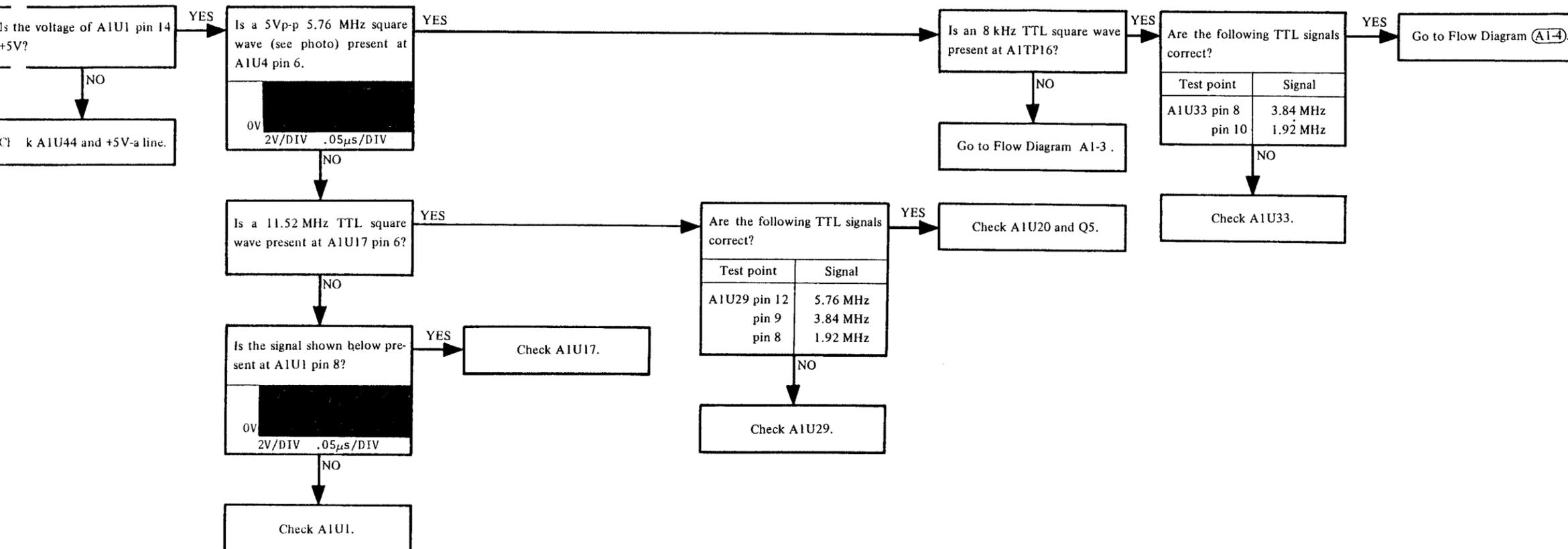
YES

| Test point | Signal |
|--------------|----------|
| A1U29 pin 12 | 5.76 MHz |
| pin 9 | 3.84 MHz |
| pin 8 | 1.92 MHz |

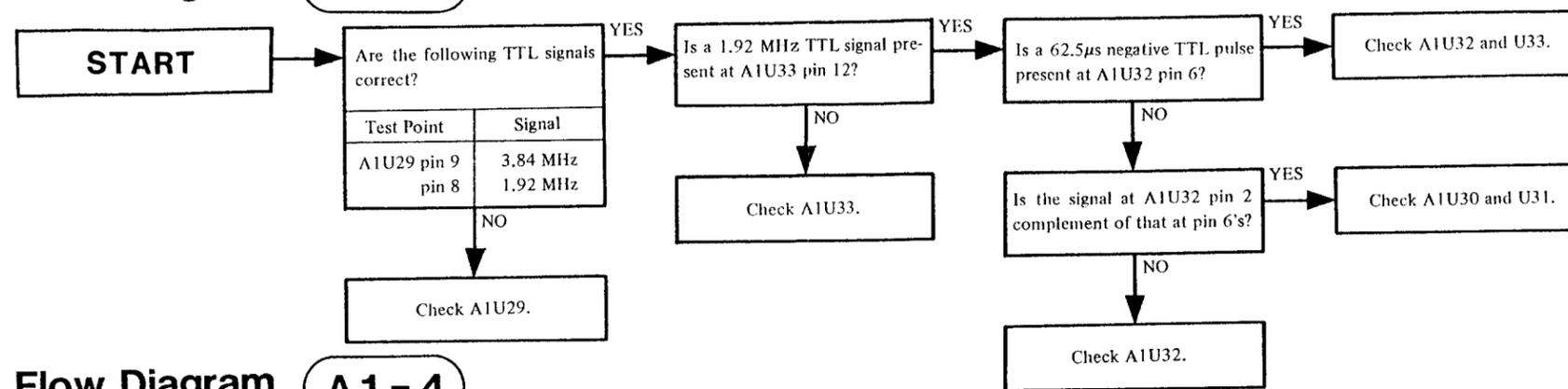
YES
 Check A1U17.

NO
 Check A1U29.

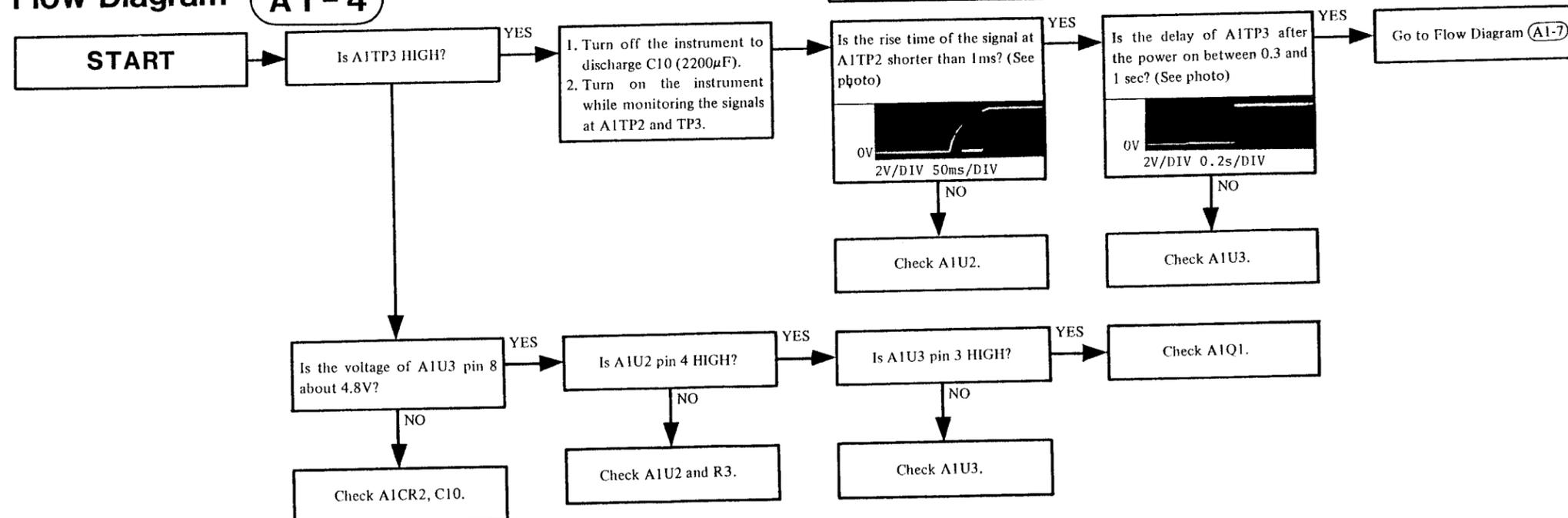
NO
 Check A1U10.



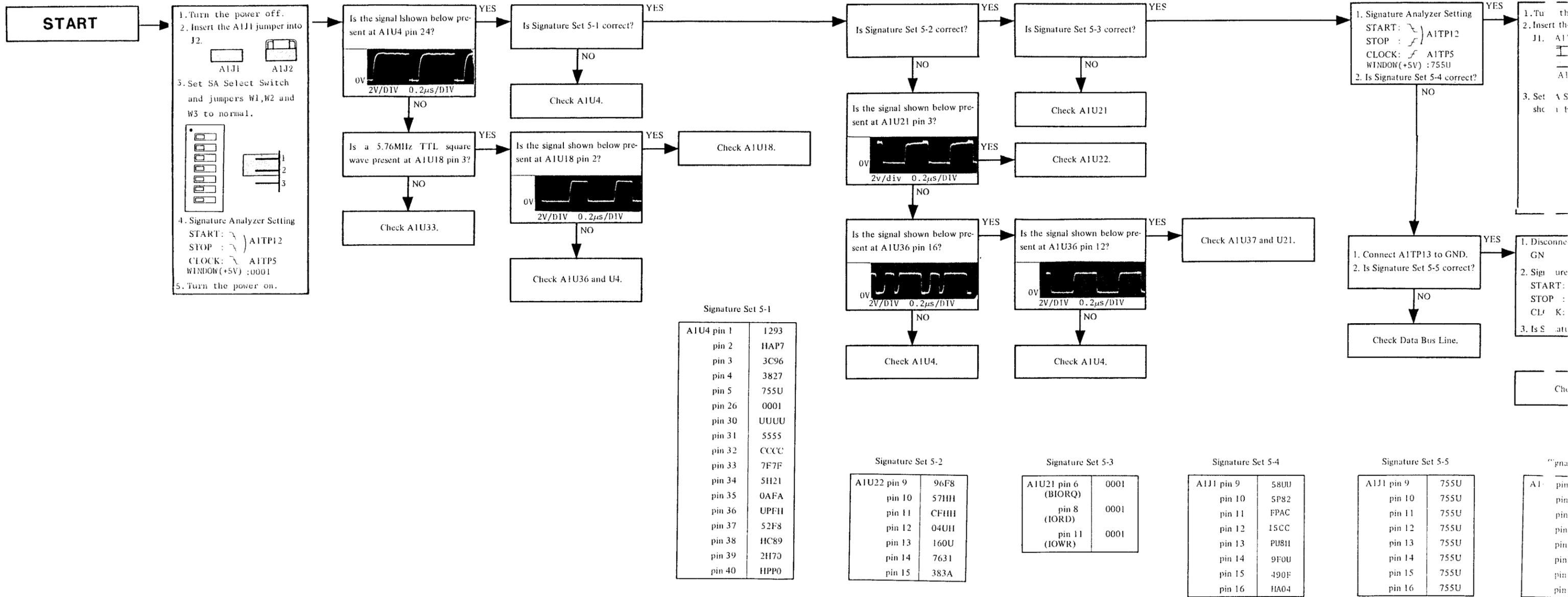
Flow Diagram A1 - 3

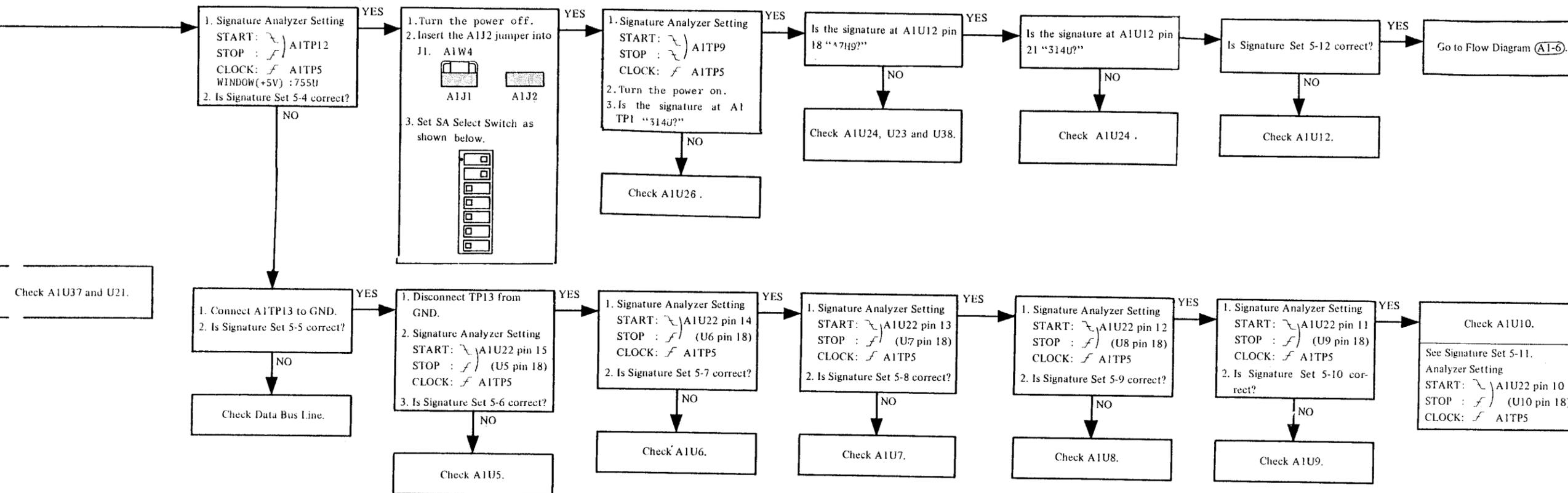


Flow Diagram A1 - 4



Flow Diagram **A1 - 5**





Signature Set 5-4

| | |
|----------|------|
| U1 pin 9 | 580U |
| pin 10 | 5P82 |
| pin 11 | FPAC |
| pin 12 | 15CC |
| pin 13 | P08H |
| pin 14 | 9F0U |
| pin 15 | 490F |
| pin 16 | HA0J |

Signature Set 5-5

| | |
|------------|------|
| A1J1 pin 9 | 755U |
| pin 10 | 755U |
| pin 11 | 755U |
| pin 12 | 755U |
| pin 13 | 755U |
| pin 14 | 755U |
| pin 15 | 755U |
| pin 16 | 755U |

Signature Set 5-6

| | |
|------------|------|
| A1U5 pin 9 | 1U9C |
| pin 10 | F42C |
| pin 11 | 3273 |
| pin 13 | CPCU |
| pin 14 | 6093 |
| pin 15 | 5H49 |
| pin 16 | 3438 |
| pin 17 | 1258 |

Signature Set 5-7

| | |
|------------|------|
| A1U6 pin 9 | 4C82 |
| pin 10 | 6C80 |
| pin 11 | 8HH8 |
| pin 13 | 90HP |
| pin 14 | 9838 |
| pin 15 | A970 |
| pin 16 | H78U |
| pin 17 | 45P9 |

Signature Set 5-8

| | |
|------------|------|
| A1U7 pin 9 | 8598 |
| pin 10 | 5U8A |
| pin 11 | 5568 |
| pin 13 | F22C |
| pin 14 | 7UUP |
| pin 15 | 22HC |
| pin 16 | 5811 |
| pin 17 | 6884 |

Signature Set 5-9

| | |
|------------|------|
| A1U8 pin 9 | 1532 |
| pin 10 | FPUC |
| pin 11 | 4P0P |
| pin 13 | 9CP5 |
| pin 14 | H633 |
| pin 15 | 106H |
| pin 16 | 51C2 |
| pin 17 | 168P |

Signature Set 5-10

| | |
|------------|------|
| A1U9 pin 9 | F30A |
| pin 10 | 6A47 |
| pin 11 | 2498 |
| pin 13 | 1F6A |
| pin 14 | 0U3U |
| pin 15 | 0A40 |
| pin 16 | 6PPF |
| pin 17 | 8UFF |

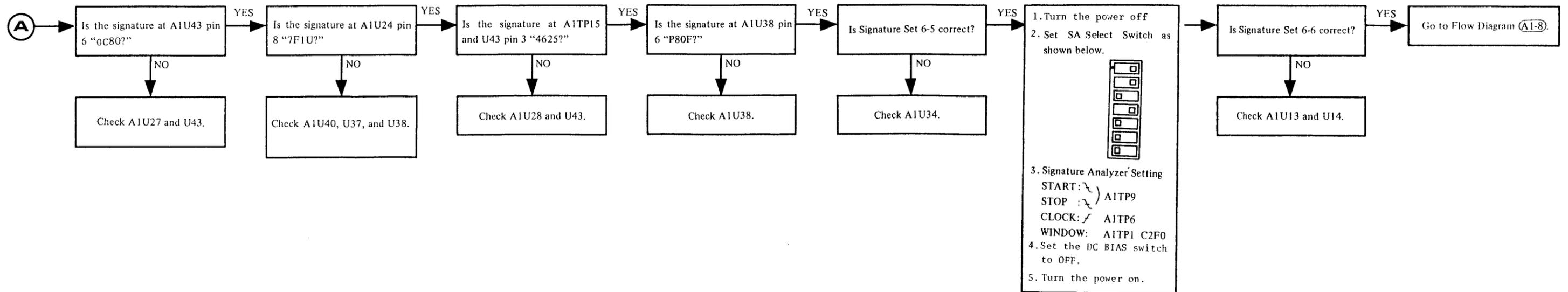
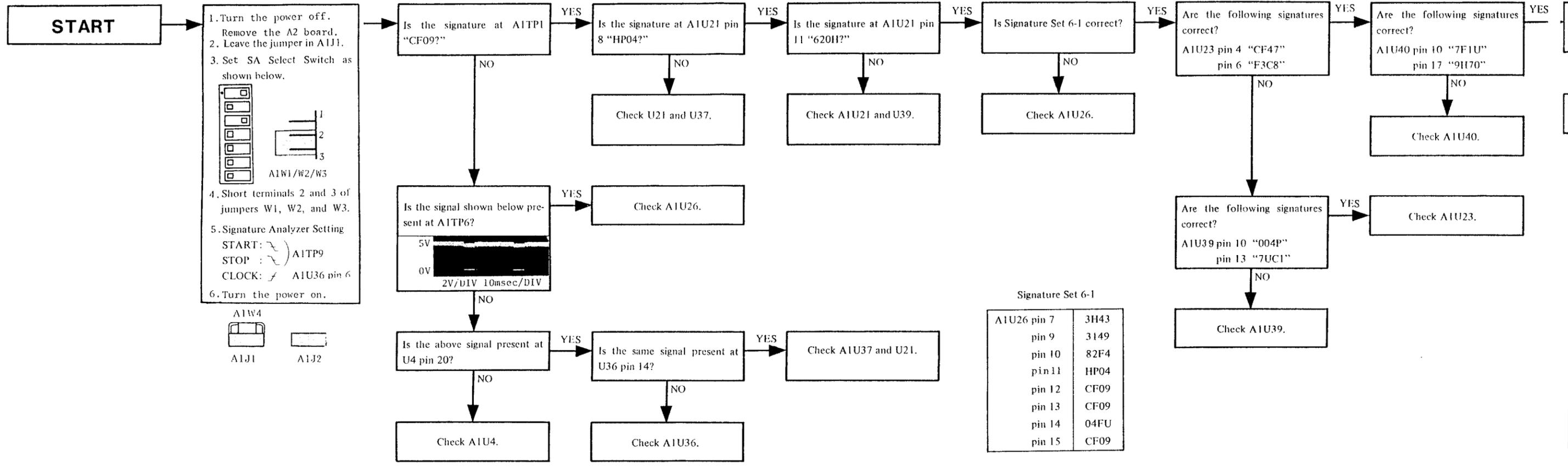
Signature Set 5-11

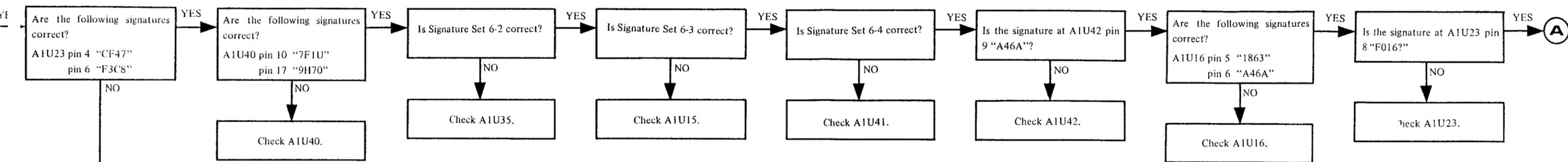
| | |
|-------------|------|
| A1U10 pin 9 | 7A36 |
| pin 10 | 7A38 |
| pin 11 | ACF6 |
| pin 13 | 3F2U |
| pin 14 | AH7A |
| pin 15 | 27U8 |
| pin 16 | C1U2 |
| pin 17 | A6F1 |

Signature Set 5-12

| | |
|-------------|------|
| A1U12 pin 9 | UC96 |
| pin 10 | 2P21 |
| pin 11 | 7528 |
| pin 13 | 4H31 |
| pin 14 | 251U |
| pin 15 | 35C0 |
| pin 16 | 2H57 |
| pin 17 | 90H2 |

Flow Diagram **A1 - 6**





Signature Set 6-2

| | |
|-------------|------|
| A1U35 pin 7 | CF09 |
| pin 9 | 164U |
| pin 10 | 44A6 |
| pin 11 | 7FP4 |
| pin 12 | P4P5 |
| pin 13 | 84U4 |
| pin 14 | P884 |
| pin 15 | 2061 |

Signature Set 6-3

| | |
|-------------|------|
| A1U15 pin 2 | 0282 |
| pin 5 | CP8C |
| pin 6 | 0C80 |
| pin 9 | 0F73 |
| pin 12 | 07U3 |
| pin 15 | F793 |
| pin 16 | A46A |
| pin 19 | AH21 |

Signature Set 6-4

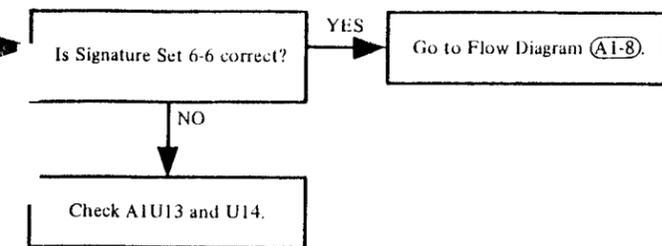
| | |
|-------------|------|
| A1U41 pin 7 | 1513 |
| pin 9 | CP9F |
| pin 10 | C923 |
| pin 11 | A8A3 |
| pin 12 | 955H |
| pin 13 | PPA0 |
| pin 14 | 195C |
| pin 15 | C65F |

Signature Set 6-5

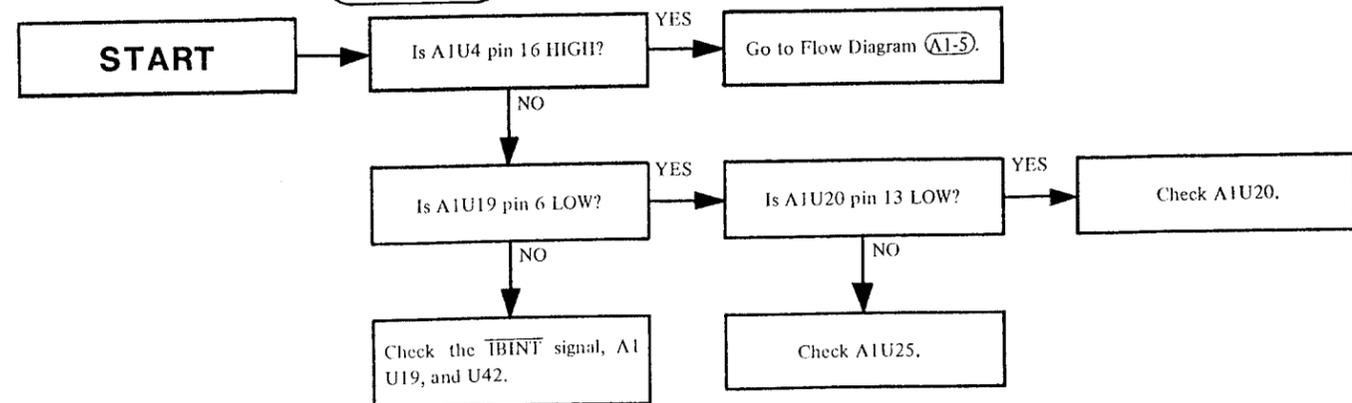
| | |
|-------------|------|
| A1U34 pin 1 | HP04 |
| pin 2 | 5939 |
| pin 3 | PF6C |
| pin 4 | 6H6F |
| pin 5 | C5HH |
| pin 6 | 2104 |
| pin 7 | U3A4 |
| pin 8 | 277U |
| pin 9 | 8741 |
| pin 11 | H19P |
| pin 12 | F019 |
| pin 13 | 239P |
| pin 14 | 491U |
| pin 15 | 05PF |
| pin 16 | 708A |
| pin 17 | 2P3P |
| pin 18 | 6UAC |
| pin 19 | P80F |

Signature Set 6-6

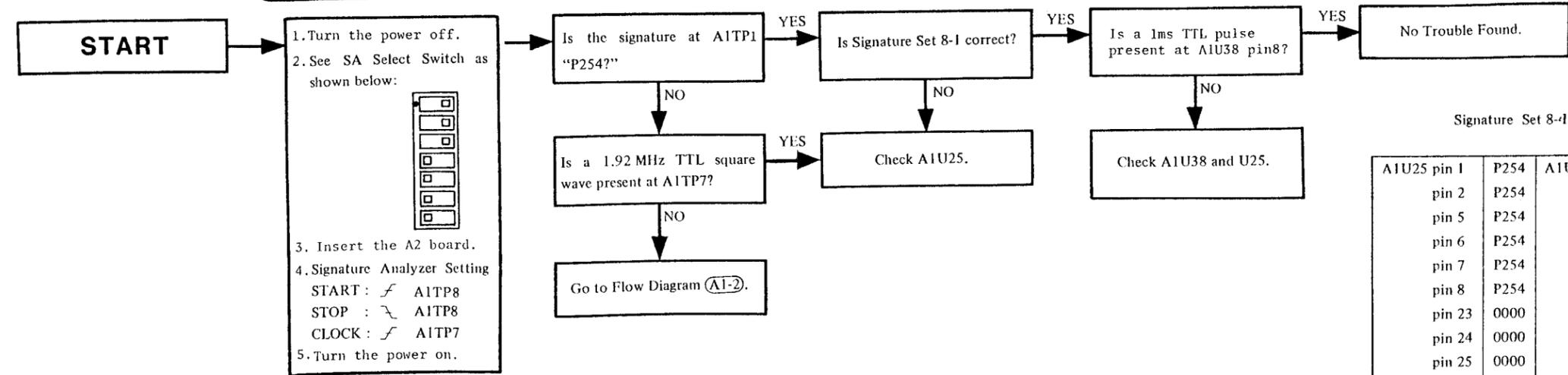
| | |
|-------------|----------------------|
| A1U14 pin 3 | 0F9P |
| pin 5 | 904A CABLE LENGTH 0m |
| pin 7 | FPU9 |
| pin 9 | C215 DC BIAS OFF |
| pin 12 | 0463 |
| pin 14 | U857 |
| pin 16 | C786 |
| pin 18 | 0U FH |



Flow Diagram A1 - 7



Flow Diagram A1 - 8



Signature Set 8-1

| | | | |
|-------------|------|--------------|------|
| A1U25 pin 1 | P254 | A1U25 pin 28 | 0000 |
| pin 2 | P254 | pin 29 | 0000 |
| pin 5 | P254 | pin 30 | 0000 |
| pin 6 | P254 | pin 31 | 0000 |
| pin 7 | P254 | pin 32 | AAHU |
| pin 8 | P254 | pin 33 | U665 |
| pin 23 | 0000 | pin 34 | 826P |
| pin 24 | 0000 | pin 35 | P254 |
| pin 25 | 0000 | pin 36 | P254 |
| pin 26 | 0000 | pin 37 | P254 |
| pin 27 | 0000 | pin 38 | P254 |
| | | pin 39 | P254 |

Flow Diagram **A1 - 9**

START

1. Turn the power off.
2. Remove the DC BIAS and Comparator boards.
3. Extend the A21 board (use extender board P/N 04276-66562).
4. Set the HP-IB address switch to 00.
5. Turn on the instrument.

Are values displayed on the front panel normal?

NO

Does DISPLAY A always indicate "OF" or "UF"?

NO

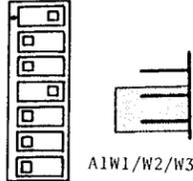
Go to Flow Diagram (A1-6).

YES

Go to Flow Diagram (A1-6).

YES

Go to Flow Diagram (A1-3).

1. Turn the power off.
 2. Set SA Select Switch as shown below.
- 
- A1W1/W2/W3
3. Short terminals 2 and 3 of jumper W1, W2 and W3.
 4. Signature Analyzer Setting
- START: A1TP9
 STOP : A1TP9
 CLOCK: A1TP6
 WINDOW(+5V) : 4058
5. Turn the power on.

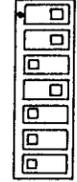
Is Signature Set 9-1 correct?

NO

Check A21U1, U4 and U8.

Signature Set 9-1

| Test point | Signature |
|-------------|-----------|
| A21U4 pin 8 | P43P |
| U4 pin 9 | A467 |
| U4 pin 10 | P43U |
| U4 pin 12 | 6754 |
| U4 pin 13 | H9AF |
| U4 pin 14 | 69C2 |
| U4 pin 15 | 0360 |
| U4 pin 16 | 2A2A |
| U4 pin 17 | 52HA |
| U4 pin 18 | 3U34 |
| U4 pin 19 | U138 |
| U4 pin 21 | 0301 |
| U4 pin 22 | 0099 |
| U4 pin 23 | 023A |

1. Turn the power off.
 2. Install the A22(DC BIAS) board with an extender board.
 3. Set SA Select Switch as shown below.
- 
4. Signature Analyzer Setting
- START: A1TP9
 STOP : A1TP9
 CLOCK: A1TP6
 WINDOW(+5V) : C2F0
5. Turn the power on.

Is Signature Set 9-2 correct?

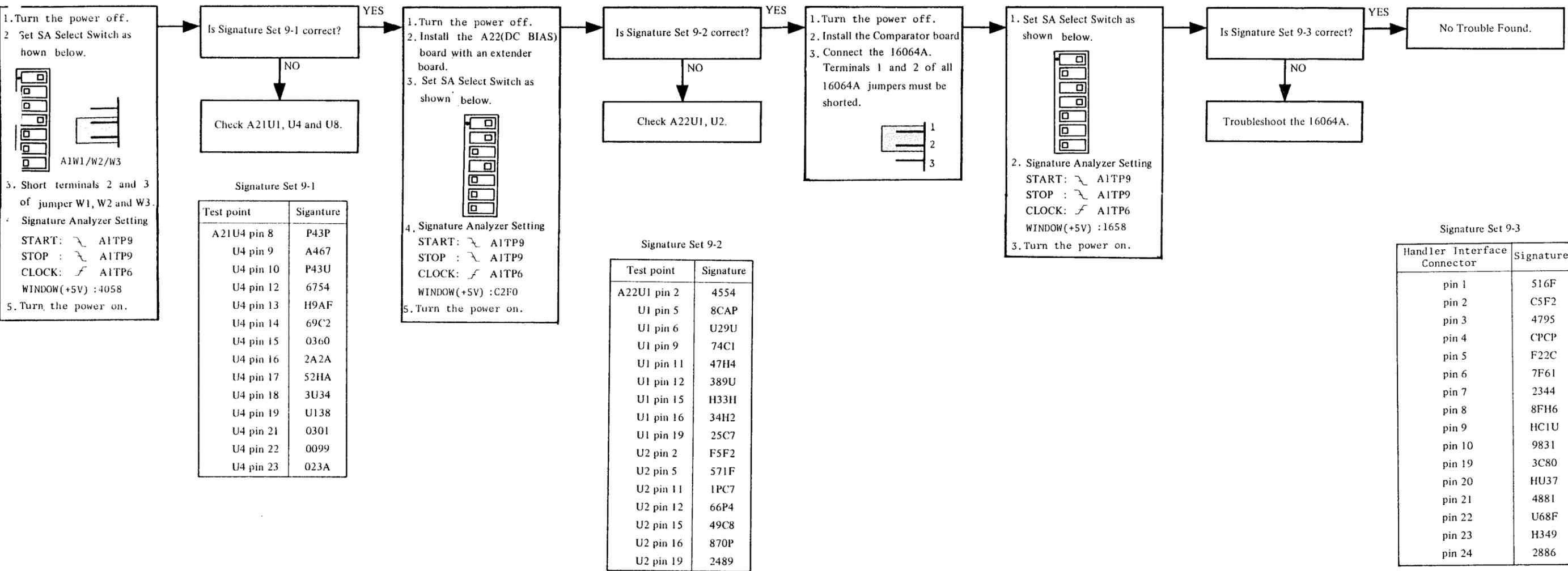
NO

Check A22U1, U2.

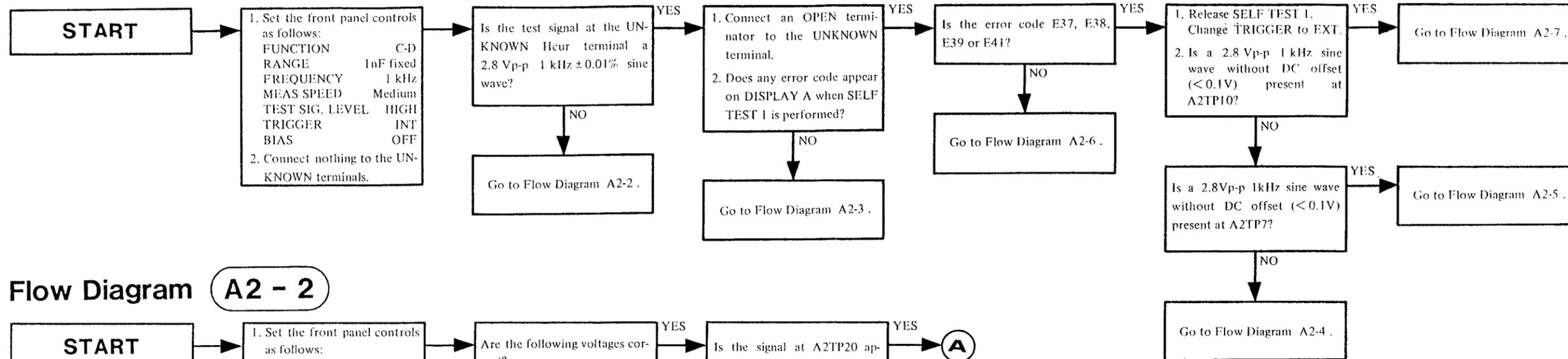
Signature Set 9-2

| Test point | Signature |
|-------------|-----------|
| A22U1 pin 2 | 4554 |
| U1 pin 5 | 8CAP |
| U1 pin 6 | U29U |
| U1 pin 9 | 74C1 |
| U1 pin 11 | 47H4 |
| U1 pin 12 | 389U |
| U1 pin 15 | H33H |
| U1 pin 16 | 34H2 |
| U1 pin 19 | 25C7 |
| U2 pin 2 | F5F2 |
| U2 pin 5 | 571F |
| U2 pin 11 | 1PC7 |
| U2 pin 12 | 66P4 |
| U2 pin 15 | 49C8 |
| U2 pin 16 | 870P |
| U2 pin 19 | 2489 |

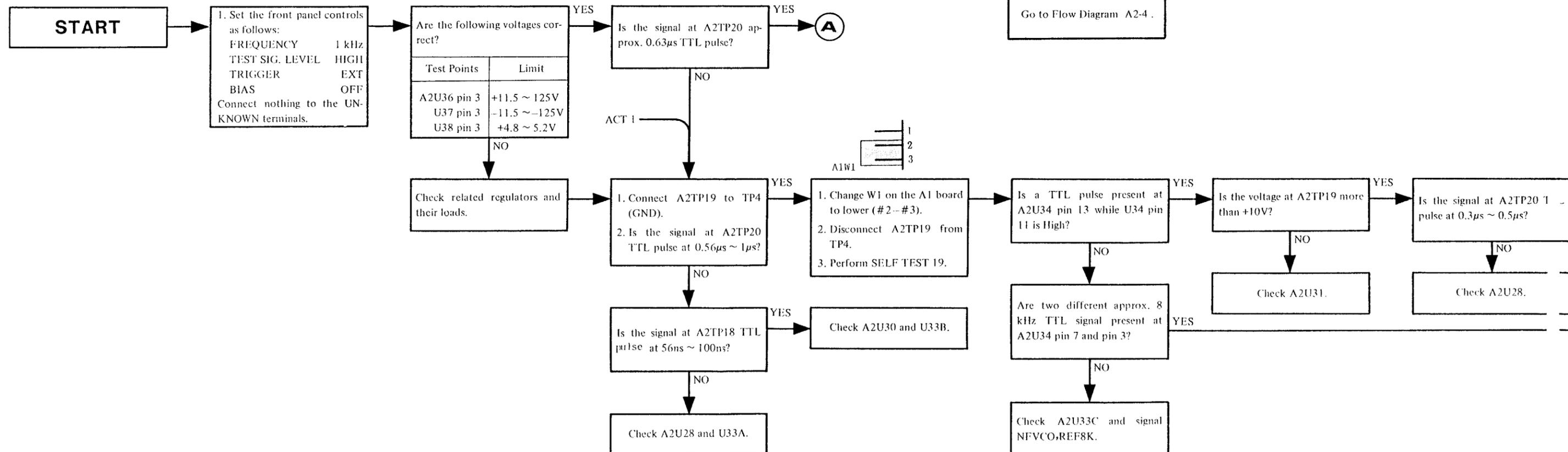
1. Turn the power off.
 2. Install the A22(DC BIAS) board with an extender board.
 3. Set SA Select Switch as shown below.
- 
4. Signature Analyzer Setting
- START: A1TP9
 STOP : A1TP9
 CLOCK: A1TP6
 WINDOW(+5V) : C2F0
5. Turn the power on.

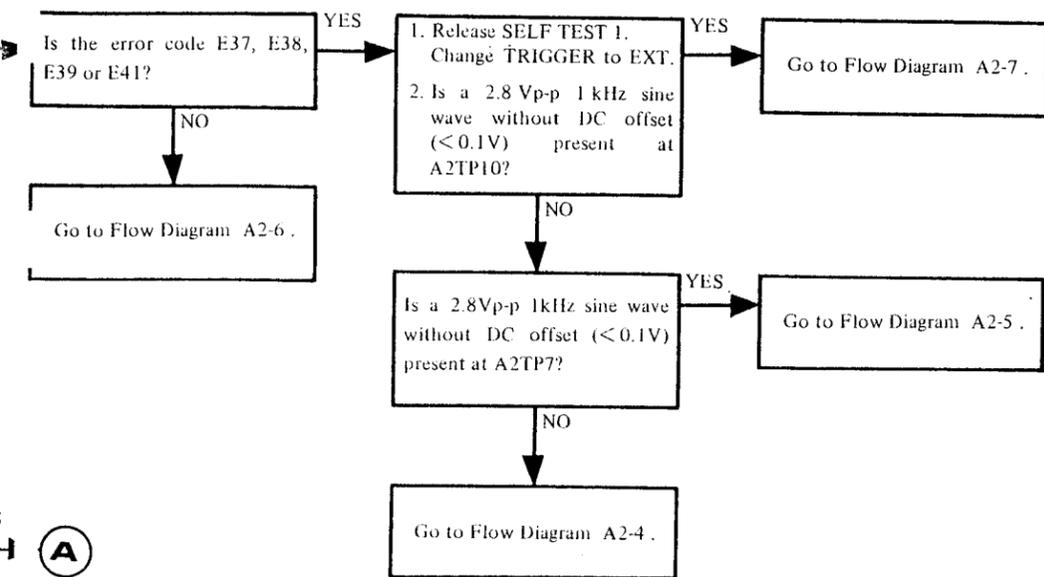


Flow Diagram A2 - 1

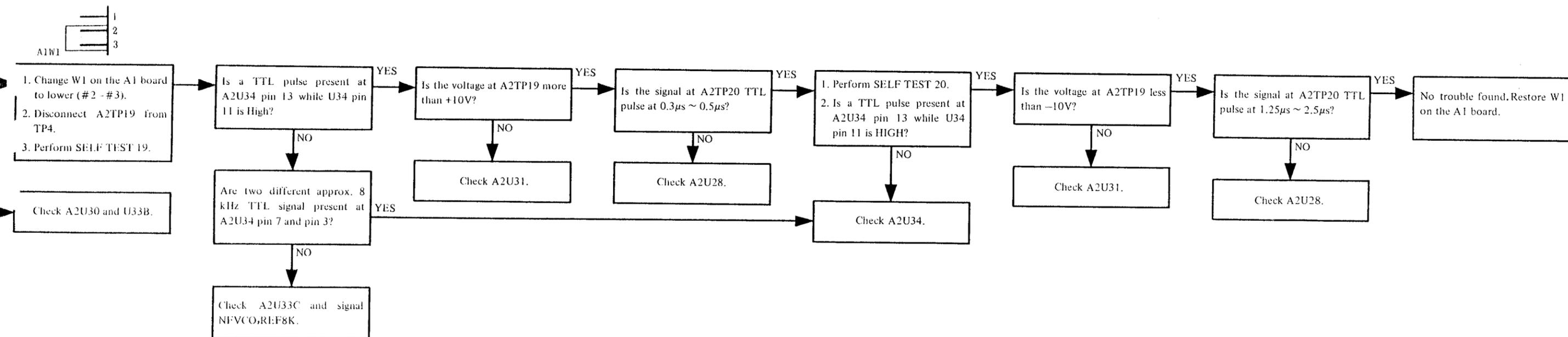


Flow Diagram A2 - 2

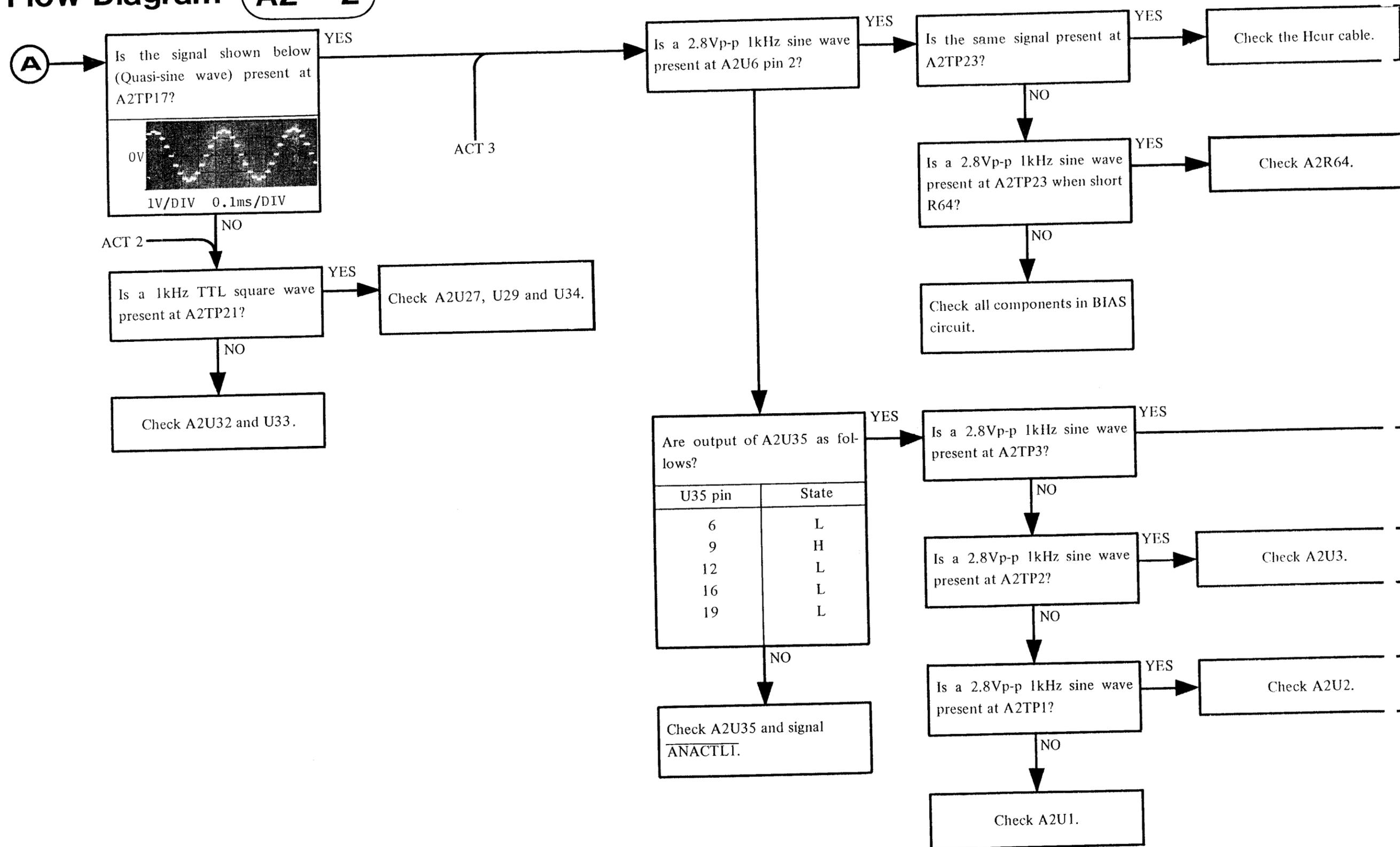


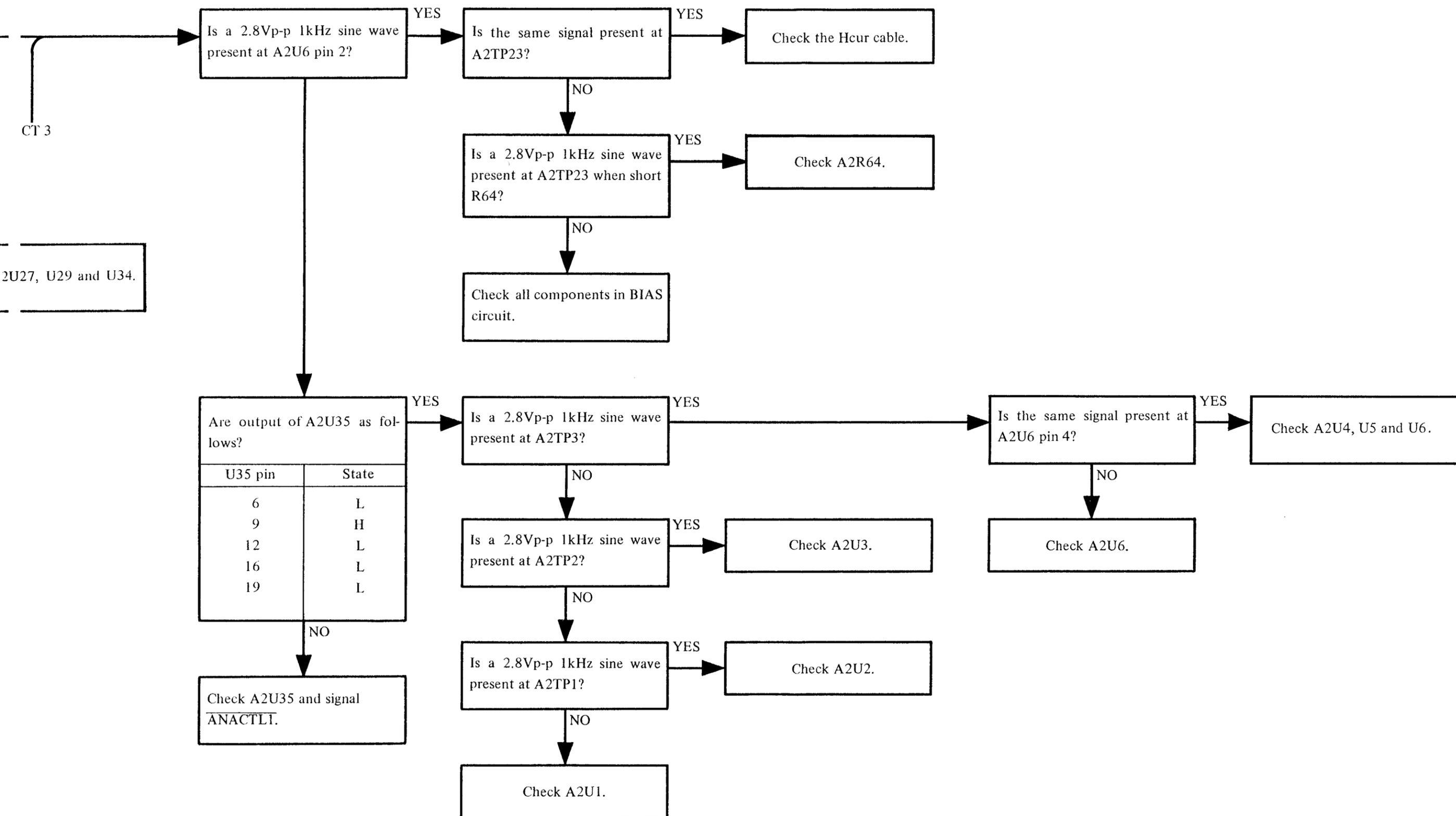


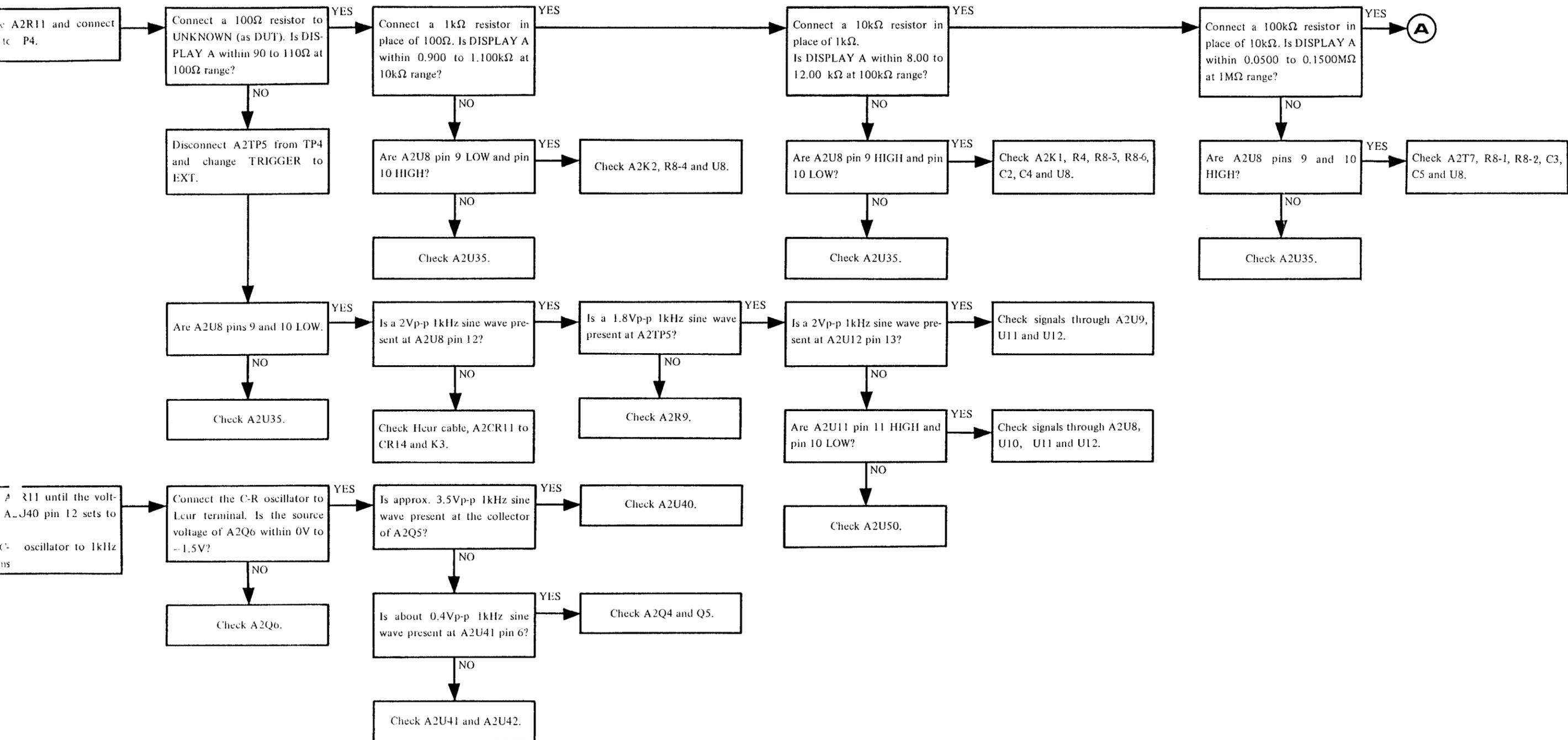
(A)



Flow Diagram **A2 - 2**







Flow Diagram

A 2 - 4

START

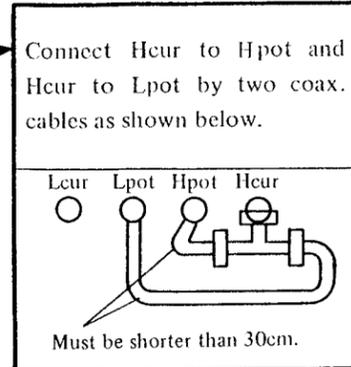
Set the front panel controls as follows:

| | |
|-----------------|-----------|
| FUNCTION | C-D |
| RANGE | 1nF fixed |
| FREQUENCY | 1 kHz |
| TEST SIG. LEVEL | HIGH |
| TRIGGER | EXT |

Are the following voltages correct?

| Test Point | Limit |
|-------------|----------------|
| A2U39 pin 3 | +4.8 ~ 5.2V |
| U46 pin 3 | -11.5 ~ -12.5V |
| U47 pin 3 | +11.5 ~ 12.5V |
| U56 pin 3 | +4.8 ~ 5.2V |

Check related regulators and loads.



Are A2U11 pin 9 Low and U48 pin 9 HIGH?

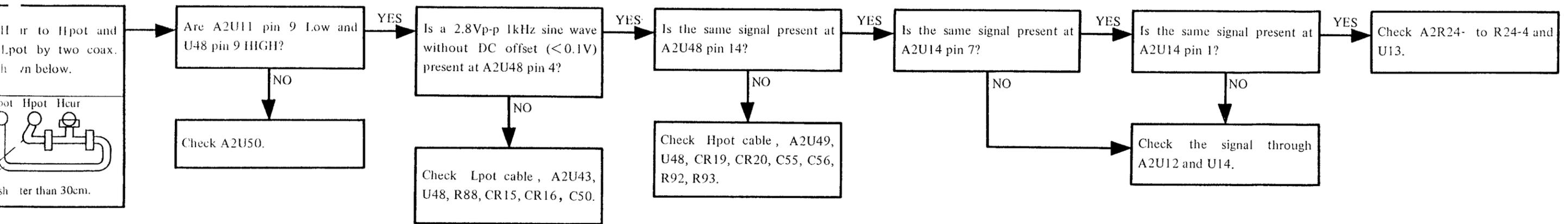
Check A2U50.

Is a 2.8Vp-p 1kHz sine wave without DC offset (<0.1V) present at A2U48 pin 4?

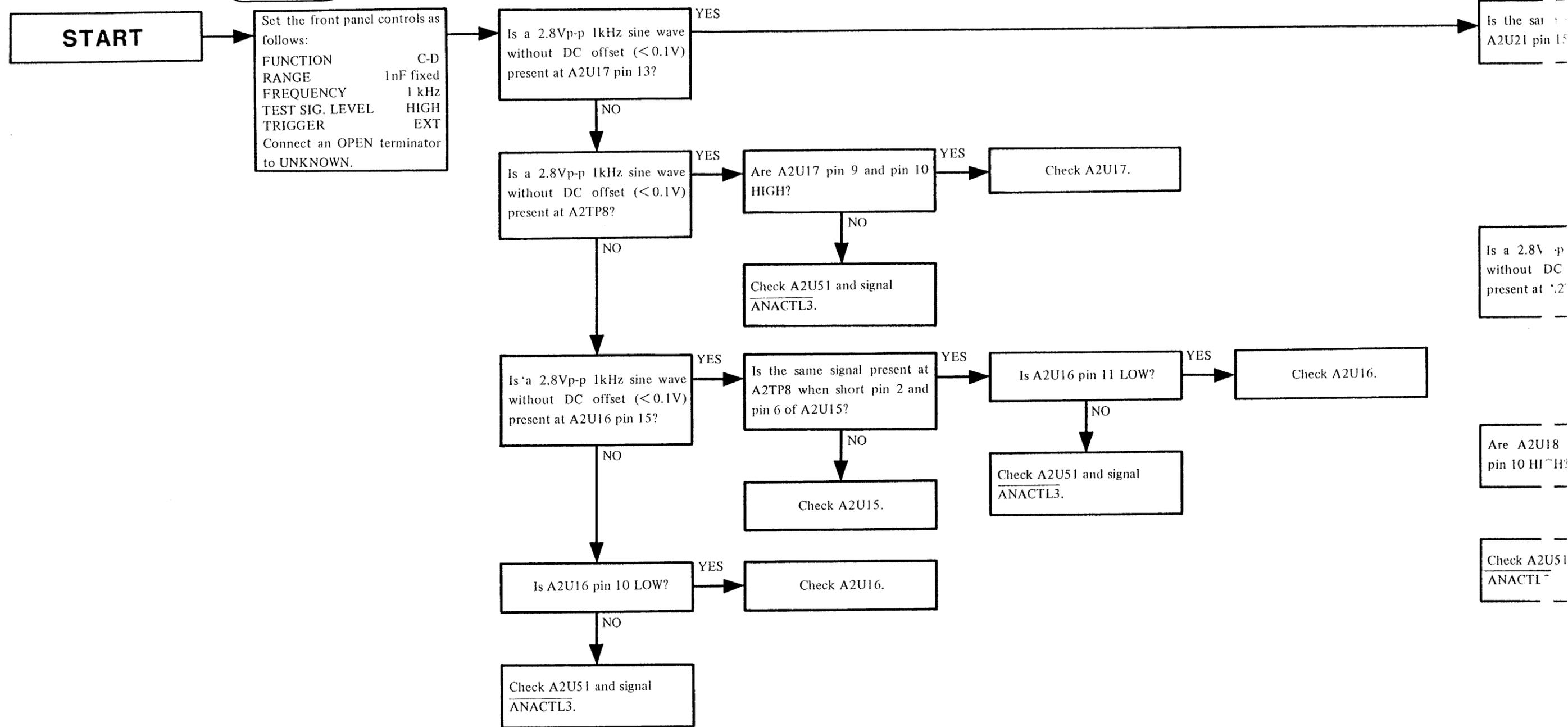
Check Lpot cable, A2U43, U48, R88, CR15, CR16, C50.

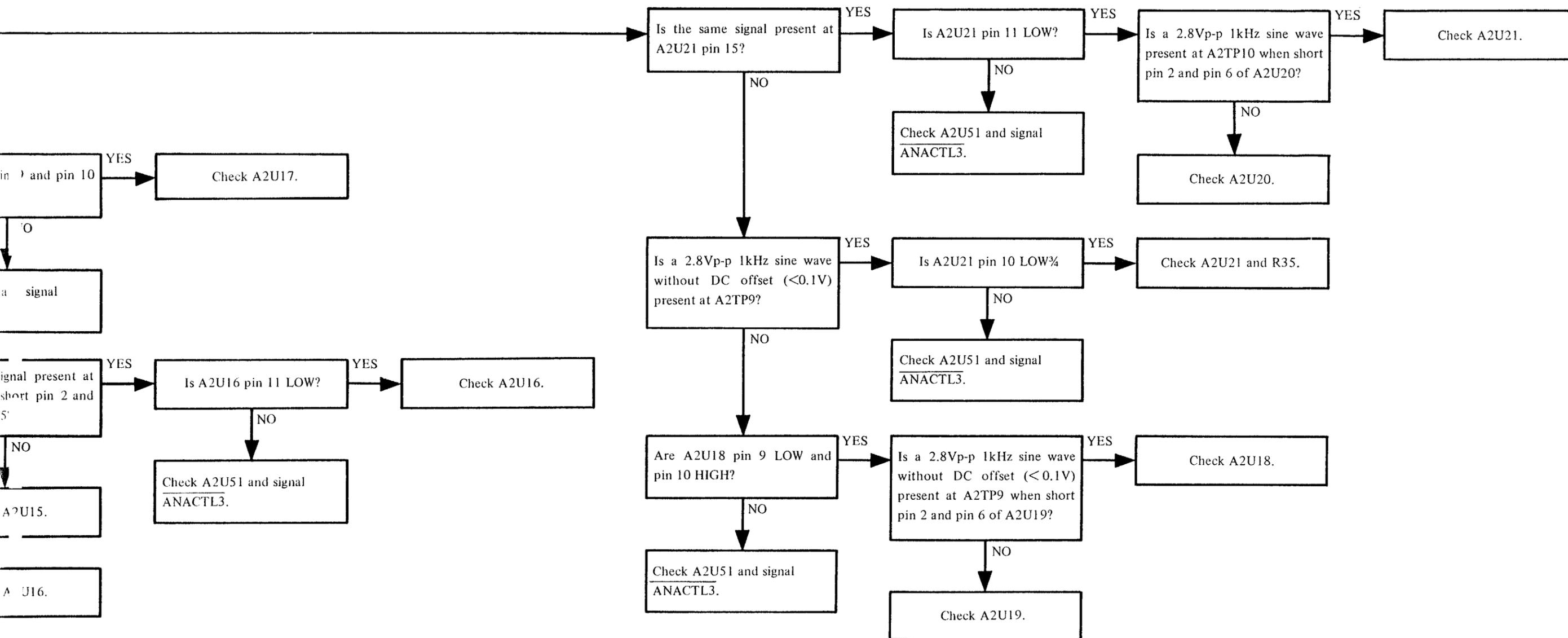
Is the same signal present at A2U48 pin 14?

Check Hpot calibration, U48, CR19, CR20, CR21, CR22, CR23, CR24, CR25, CR26, CR27, CR28, CR29, CR30, CR31, CR32, CR33, CR34, CR35, CR36, CR37, CR38, CR39, CR40, CR41, CR42, CR43, CR44, CR45, CR46, CR47, CR48, CR49, CR50, CR51, CR52, CR53, CR54, CR55, CR56, CR57, CR58, CR59, CR60, CR61, CR62, CR63, CR64, CR65, CR66, CR67, CR68, CR69, CR70, CR71, CR72, CR73, CR74, CR75, CR76, CR77, CR78, CR79, CR80, CR81, CR82, CR83, CR84, CR85, CR86, CR87, CR88, CR89, CR90, CR91, CR92, CR93, CR94, CR95, CR96, CR97, CR98, CR99, CR100.

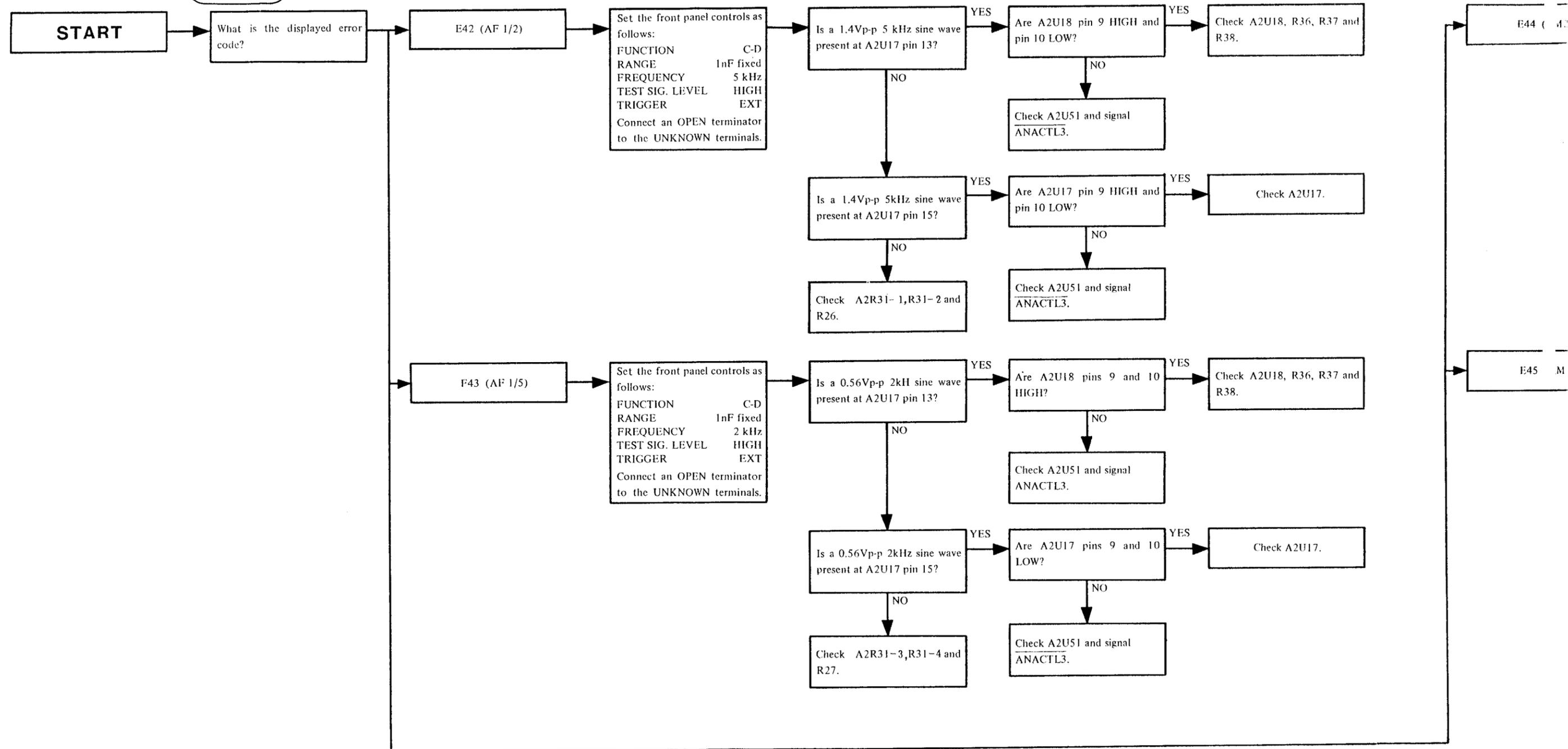


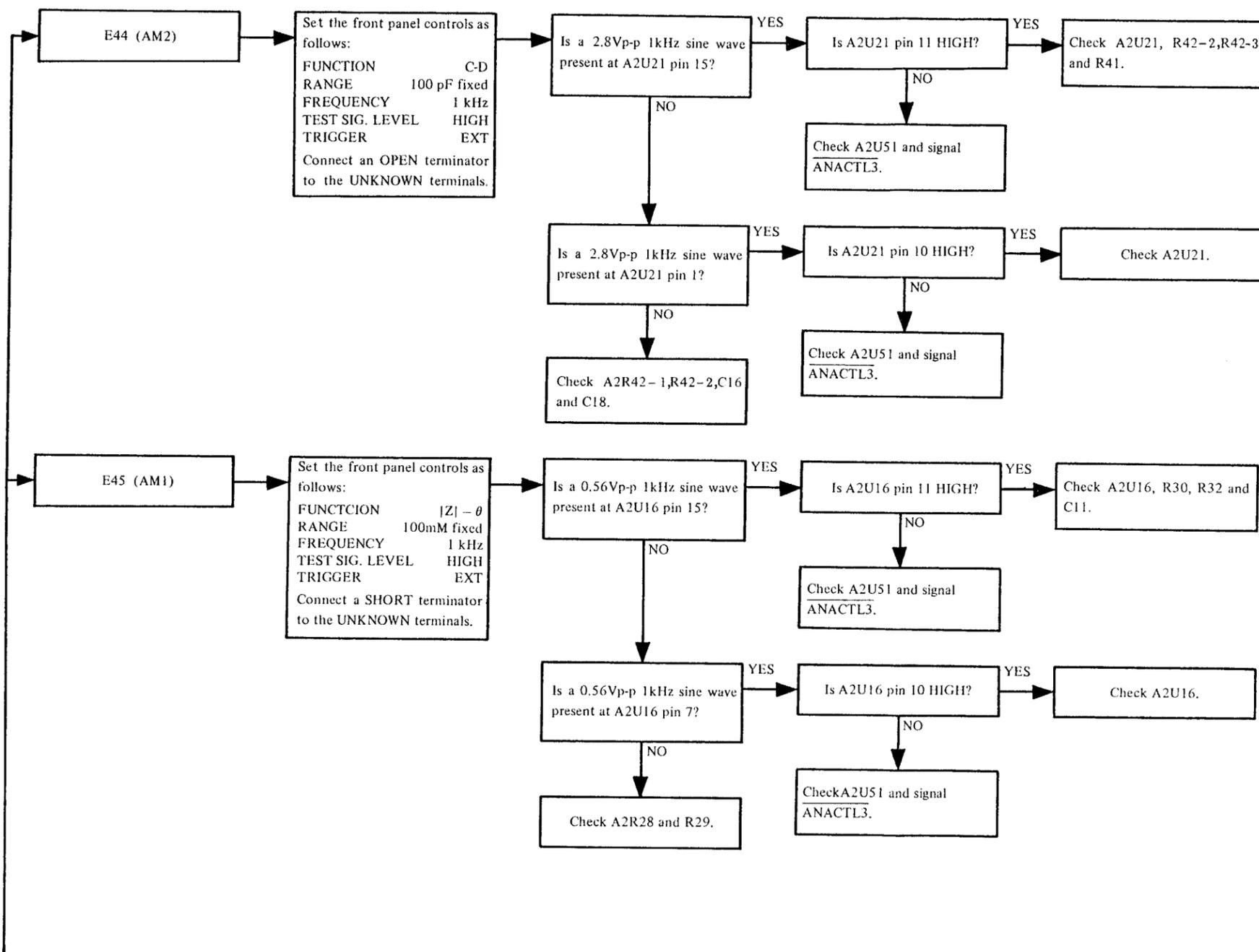
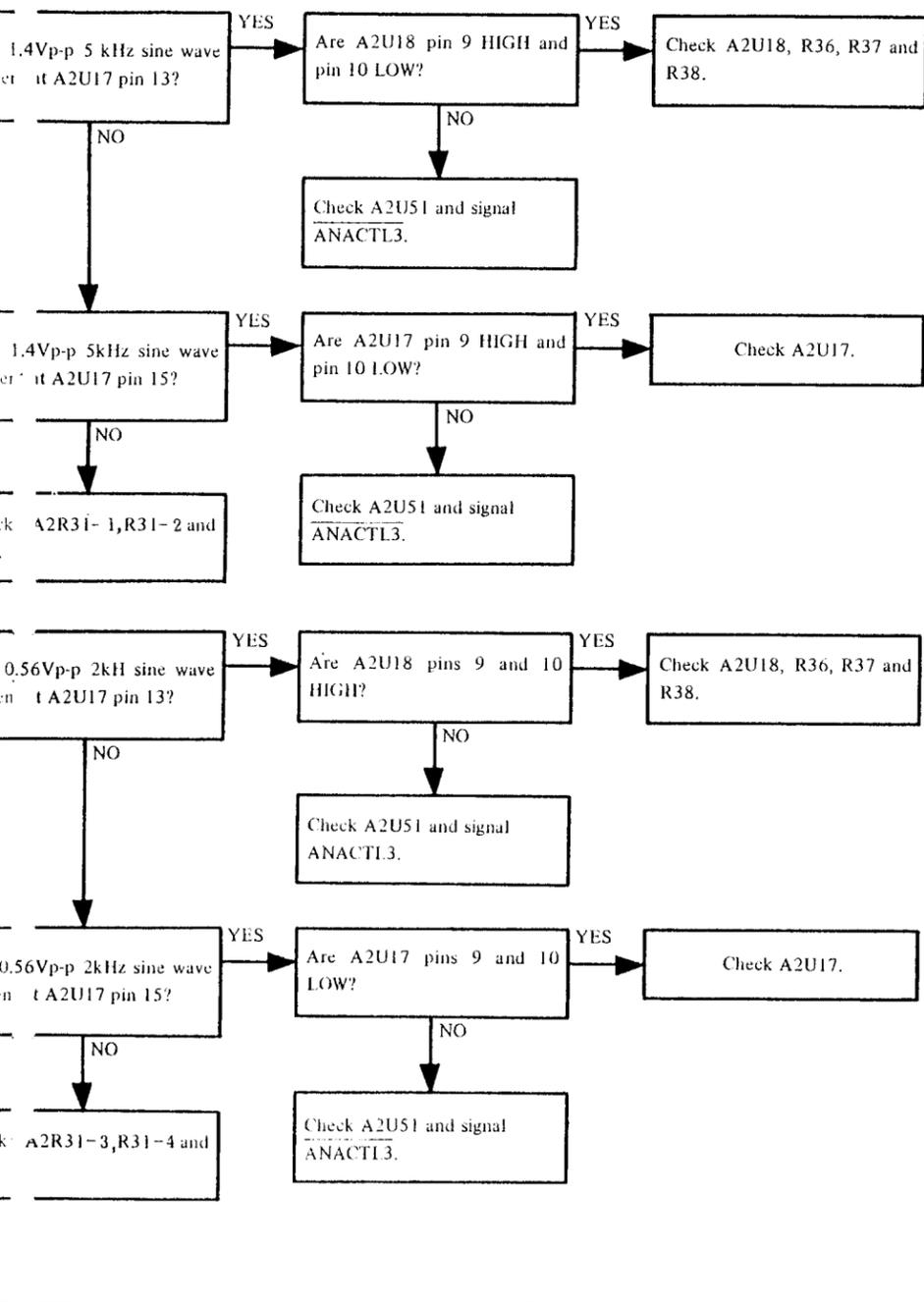
Flow Diagram **A2 - 5**





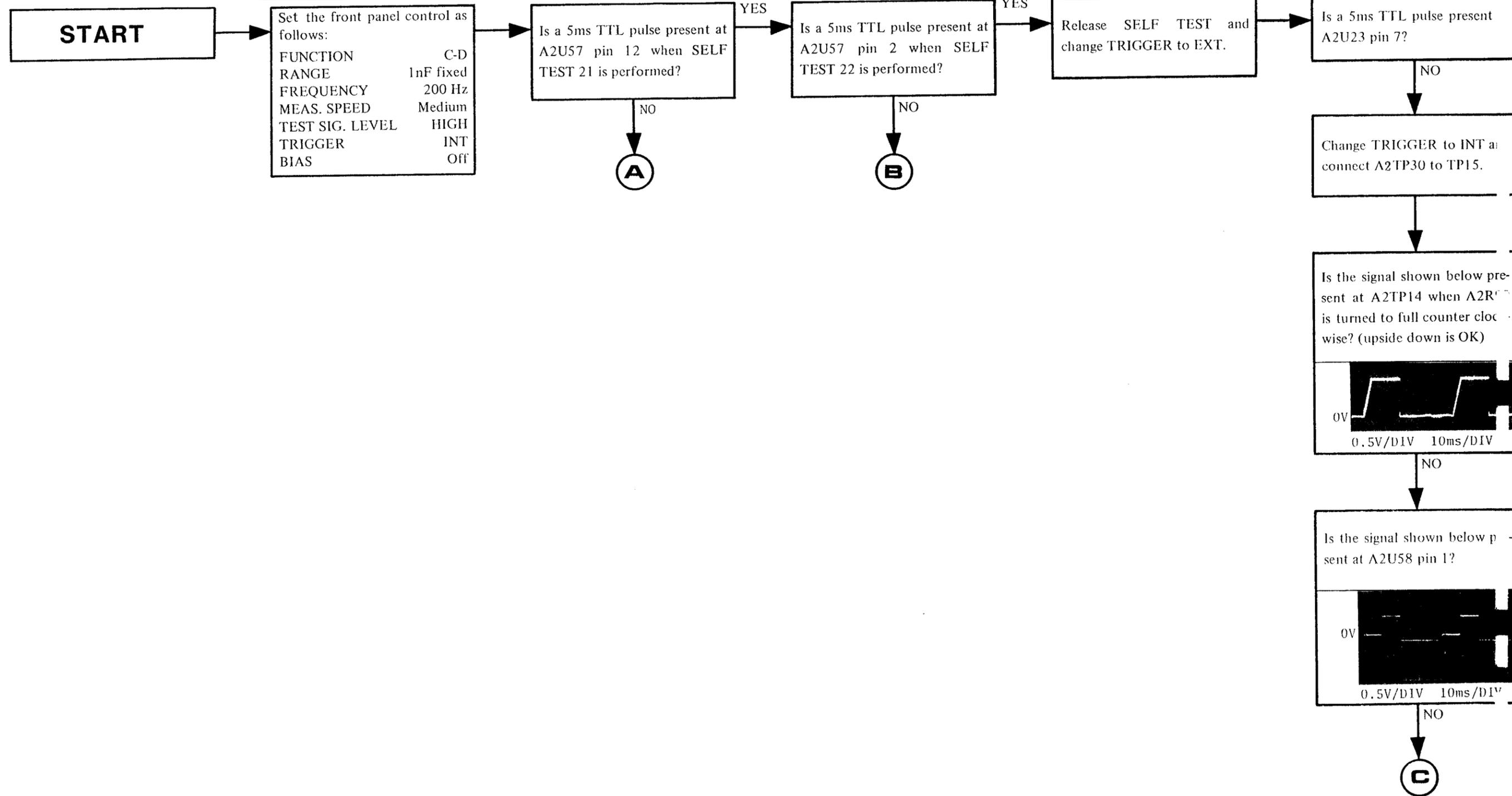
Flow Diagram **A2 - 6**

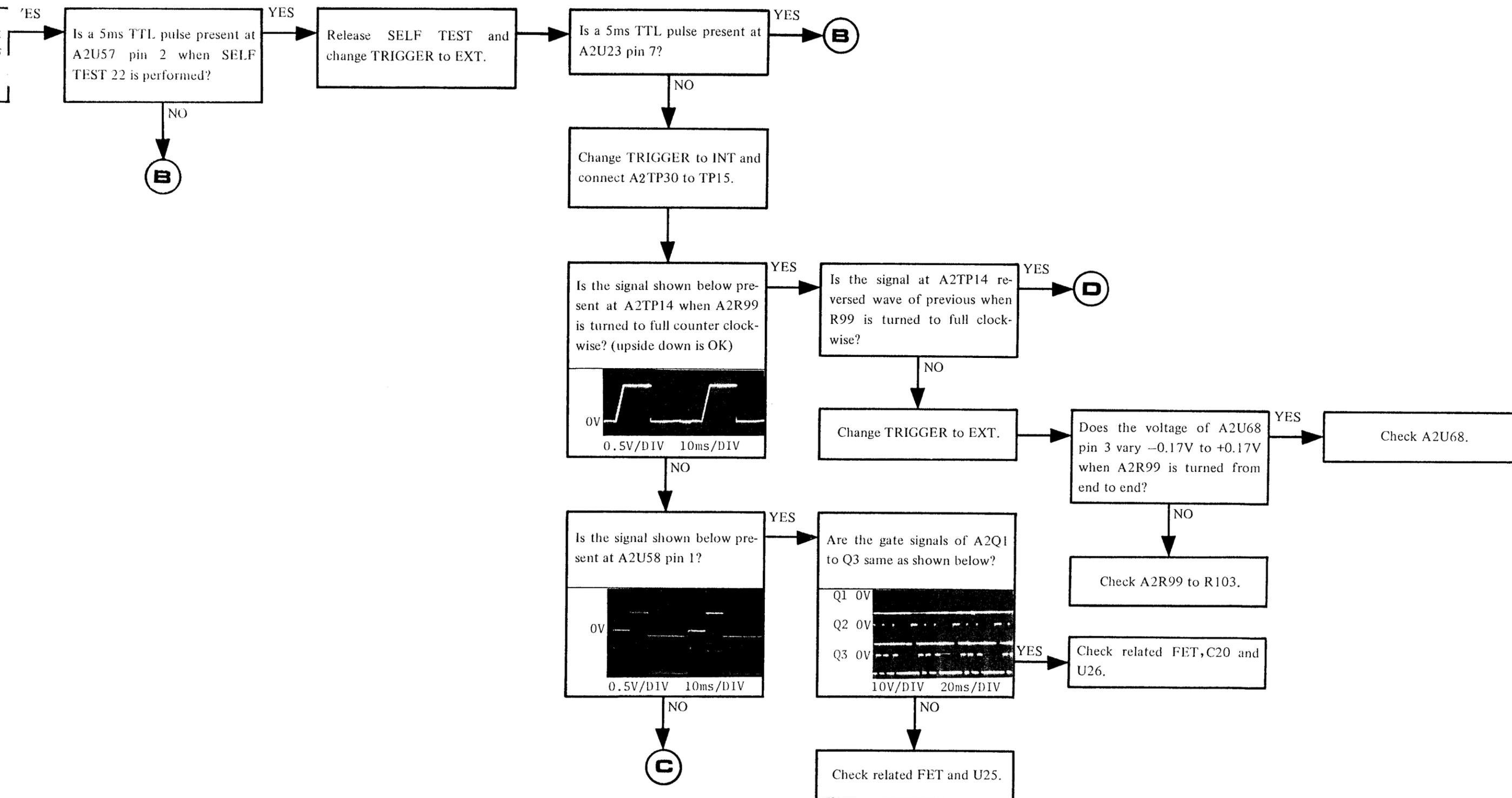




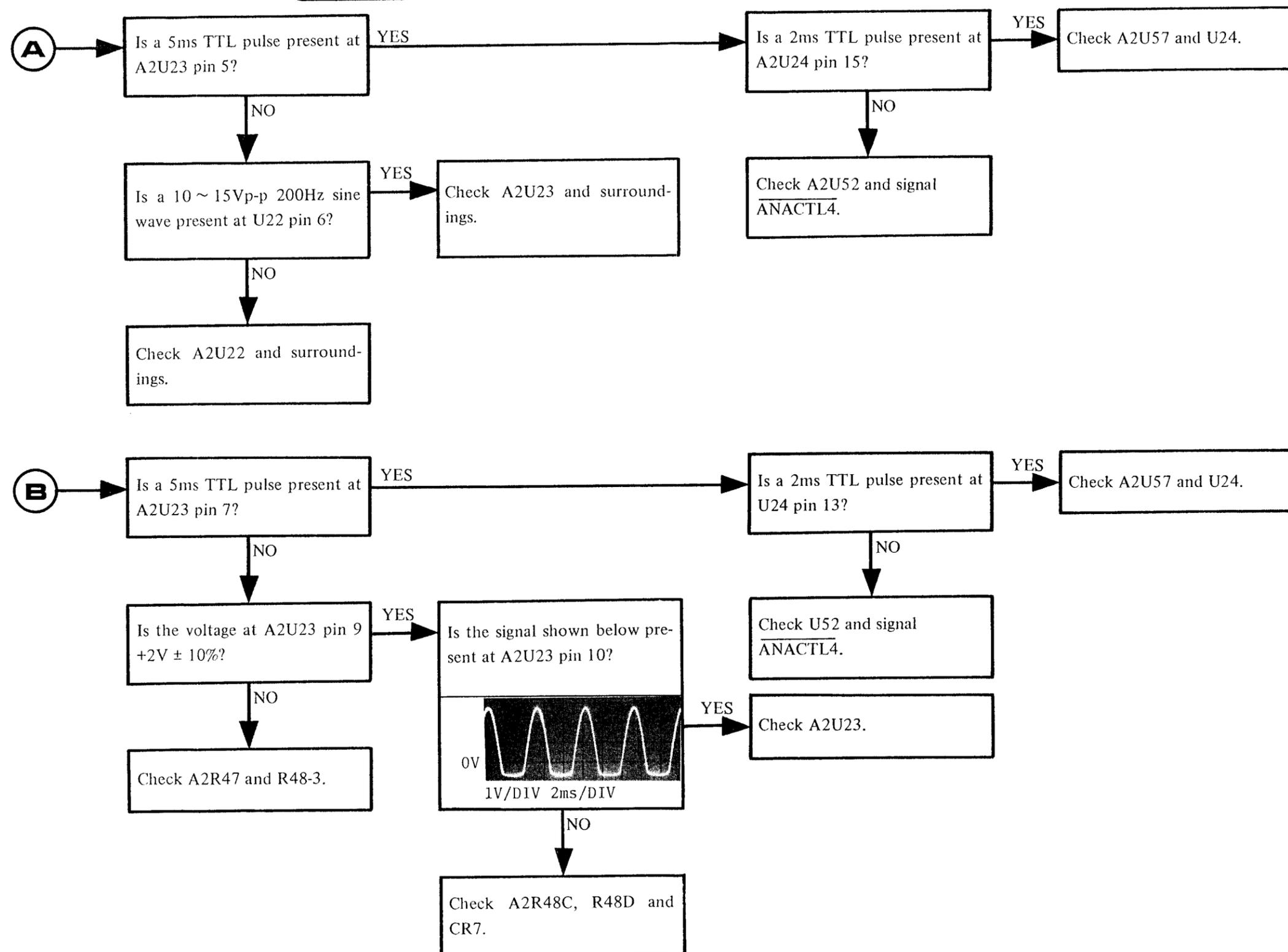
Flow Diagram

A2 - 7

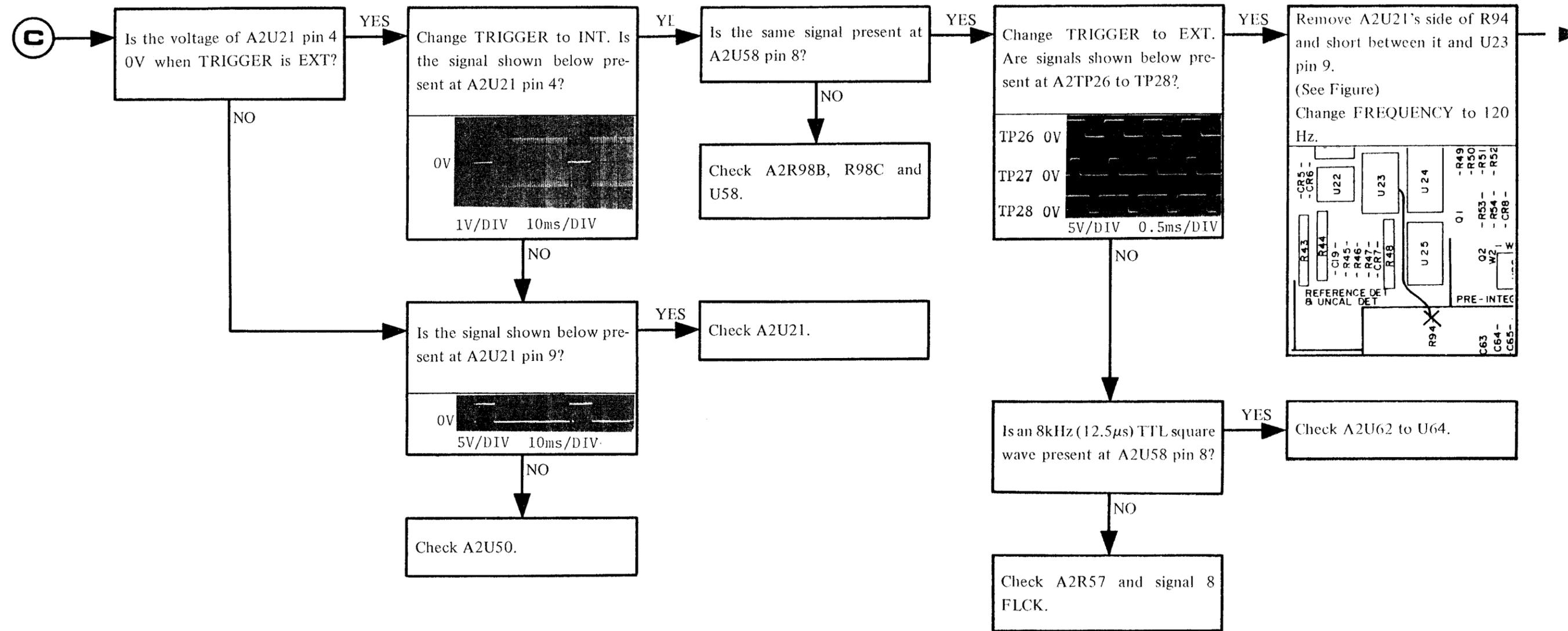


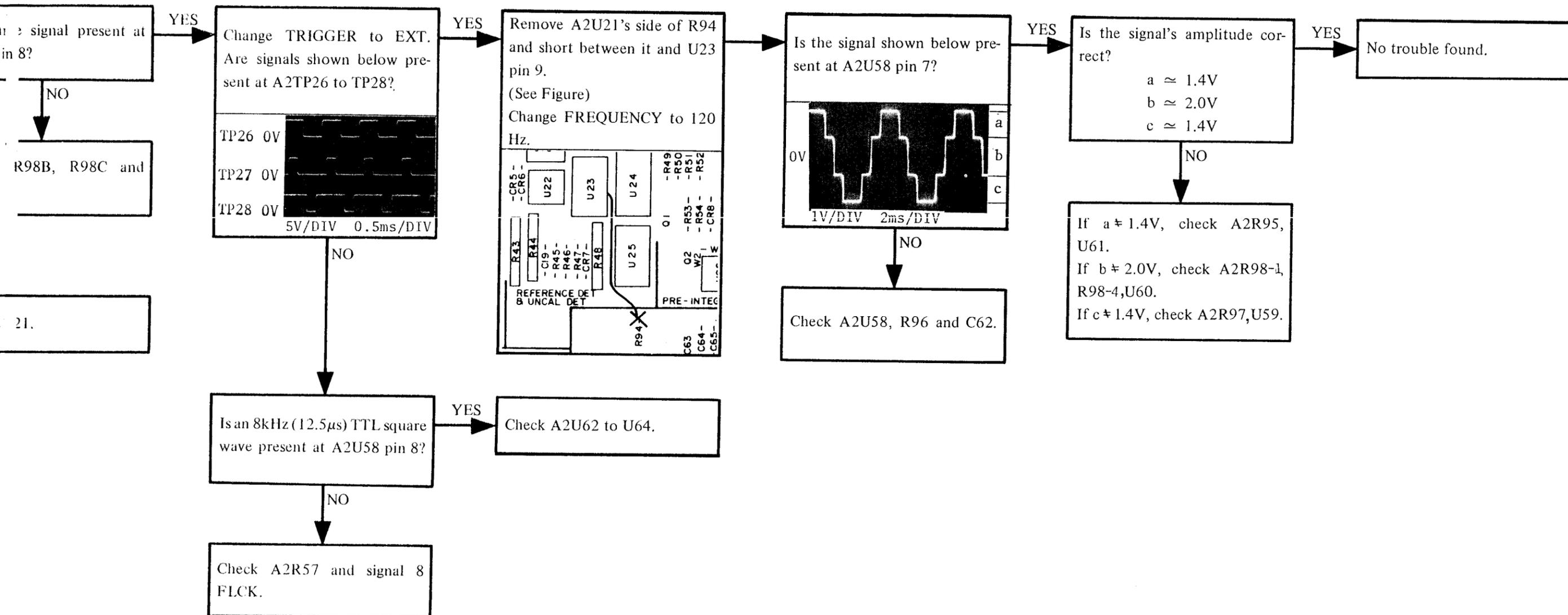


Flow Diagram **A2 - 7**

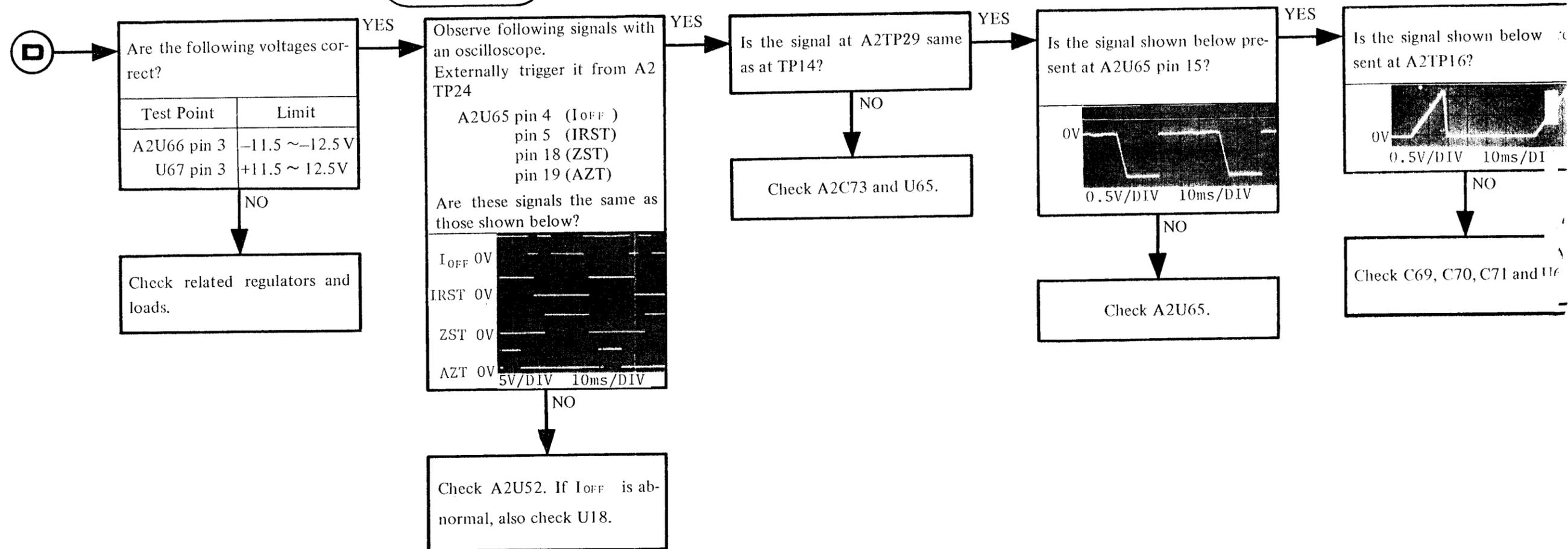


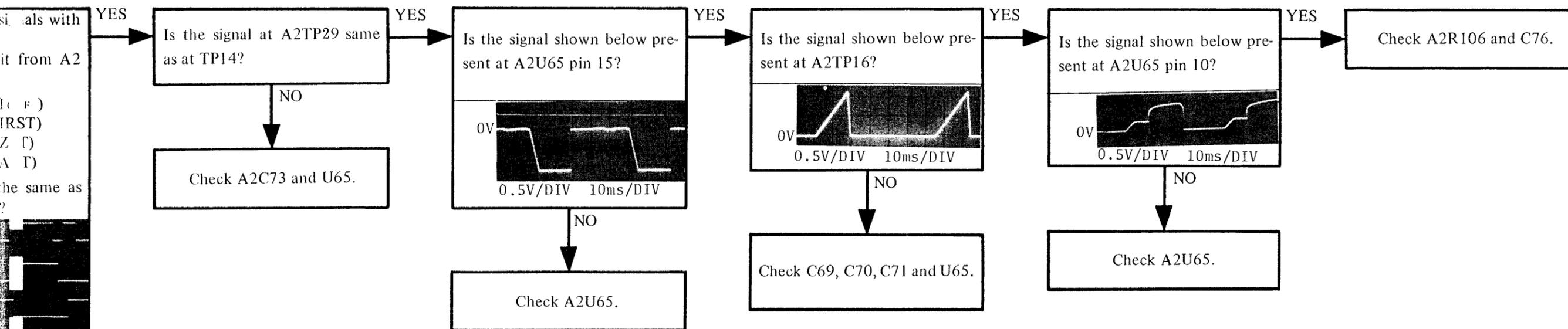
Flow Diagram **A2 - 7**





Flow Diagram **A2 - 7**

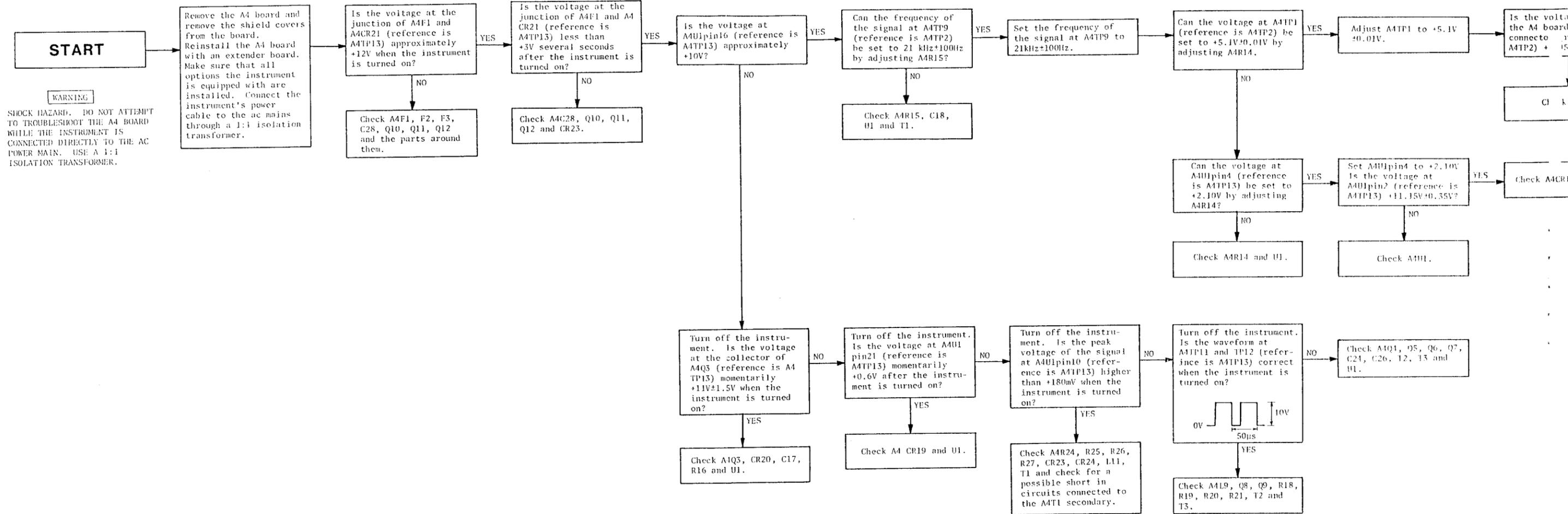


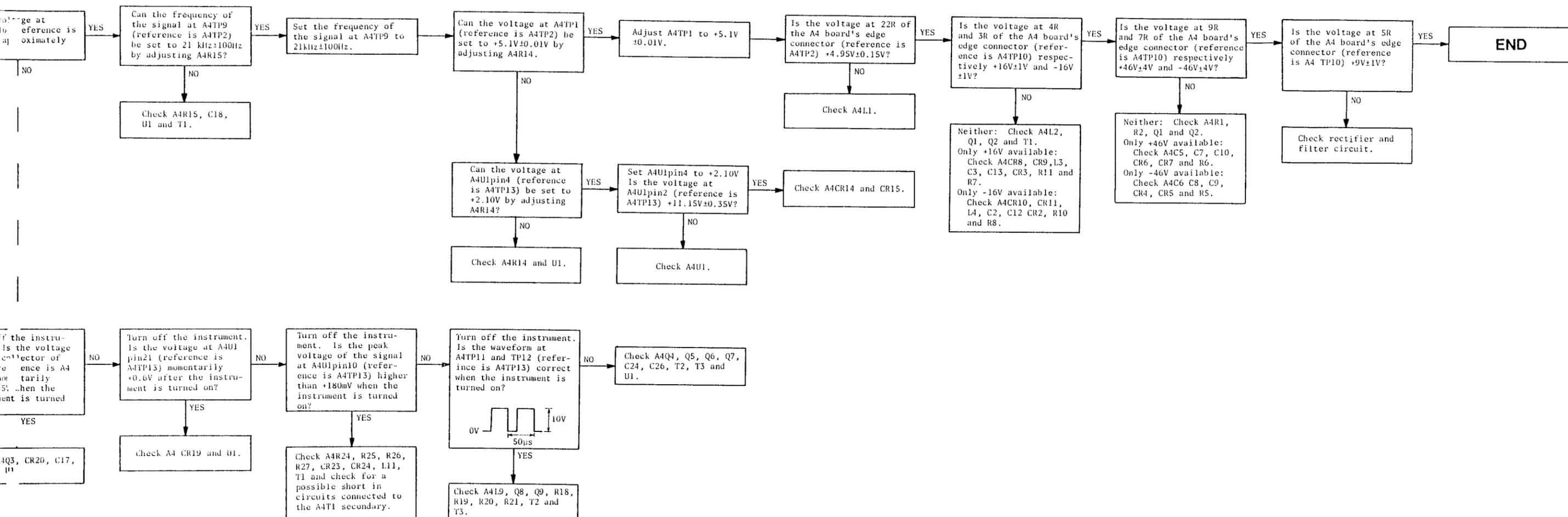


signals with
it from A2
(F)
(IRST)
(Z)
(A)
the same as
?
10ms/DIV

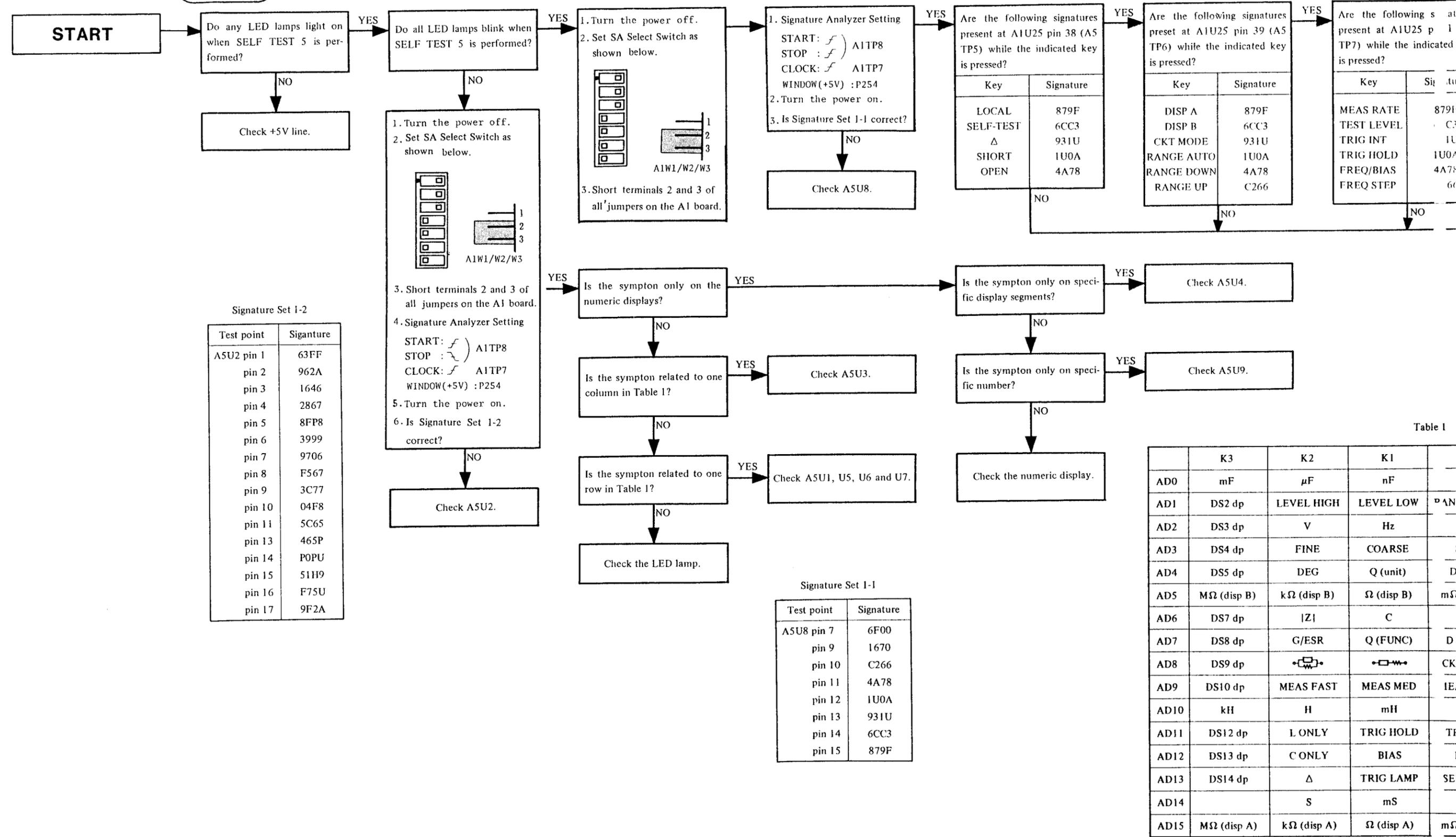
ic. ? is ab-
U18.

Flow Diagram A4 - 1





Flow Diagram **A5 - 1**



Signature Set 1-2

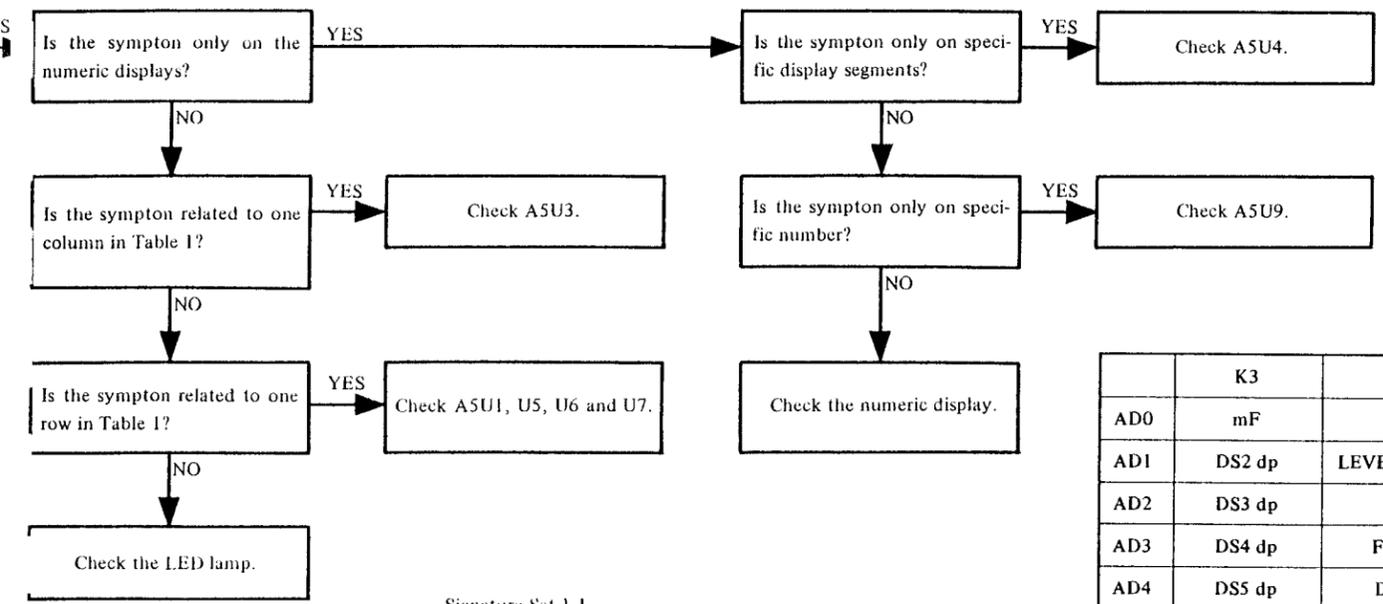
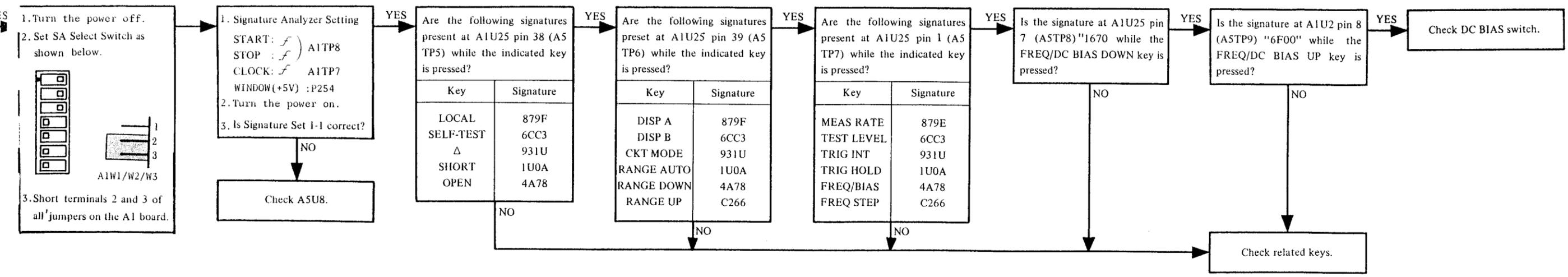
| Test point | Signature |
|------------|-----------|
| A5U2 pin 1 | 63FF |
| pin 2 | 962A |
| pin 3 | 1646 |
| pin 4 | 2867 |
| pin 5 | 8FP8 |
| pin 6 | 3999 |
| pin 7 | 9706 |
| pin 8 | F567 |
| pin 9 | 3C77 |
| pin 10 | 04F8 |
| pin 11 | 5C65 |
| pin 13 | 465P |
| pin 14 | POPU |
| pin 15 | 51H9 |
| pin 16 | F75U |
| pin 17 | 9F2A |

Signature Set 1-1

| Test point | Signature |
|------------|-----------|
| A5U8 pin 7 | 6F00 |
| pin 9 | 1670 |
| pin 10 | C266 |
| pin 11 | 4A78 |
| pin 12 | 1U0A |
| pin 13 | 931U |
| pin 14 | 6CC3 |
| pin 15 | 879F |

Table 1

| | K3 | K2 | K1 | |
|------|-------------|-------------|------------|----|
| AD0 | mF | μF | nF | |
| AD1 | DS2 dp | LEVEL HIGH | LEVEL LOW | PA |
| AD2 | DS3 dp | V | Hz | |
| AD3 | DS4 dp | FINE | COARSE | |
| AD4 | DS5 dp | DEG | Q (unit) | D |
| AD5 | MΩ (disp B) | kΩ (disp B) | Ω (disp B) | mΩ |
| AD6 | DS7 dp | Z | C | |
| AD7 | DS8 dp | G/ESR | Q (FUNC) | D |
| AD8 | DS9 dp | | | CK |
| AD9 | DS10 dp | MEAS FAST | MEAS MED | IE |
| AD10 | | kH | H | mH |
| AD11 | DS12 dp | L ONLY | TRIG HOLD | TF |
| AD12 | DS13 dp | C ONLY | BIAS | I |
| AD13 | DS14 dp | Δ | TRIG LAMP | SE |
| AD14 | | S | mS | |
| AD15 | MΩ (disp A) | kΩ (disp A) | Ω (disp A) | mΩ |



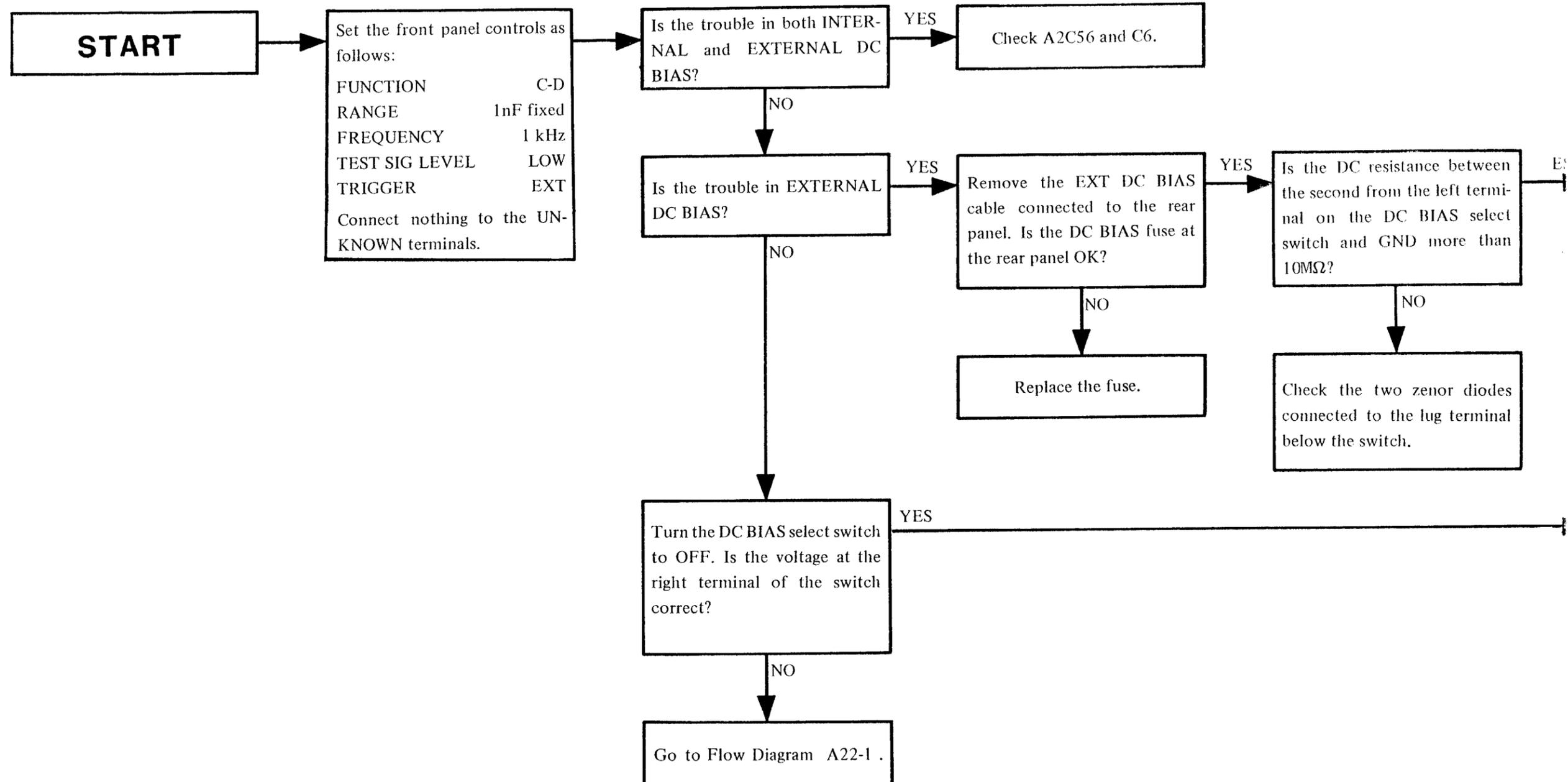
Signature Set 1-1

| Test point | Signature |
|------------|-----------|
| A5U8 pin 7 | 6F00 |
| pin 9 | 1670 |
| pin 10 | C266 |
| pin 11 | 4A78 |
| pin 12 | 1U0A |
| pin 13 | 931U |
| pin 14 | 6CC3 |
| pin 15 | 879F |

Table 1

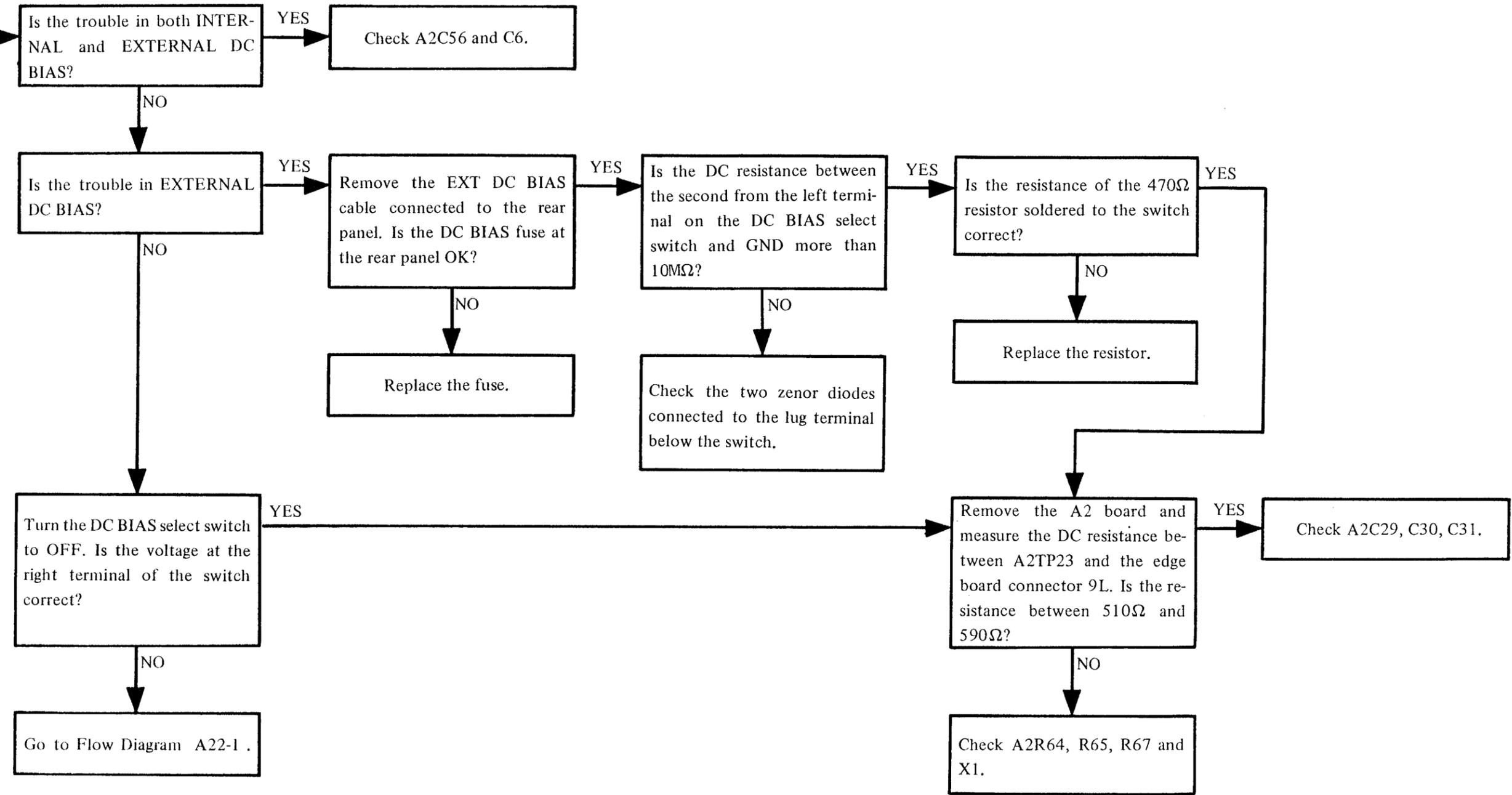
| | K3 | K2 | K1 | K0 | KB3 | KB2 | KB1 | KB0 |
|------|---------------------|---------------------|-------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| AD0 | mF | μ F | nF | pF | DS1 2 ³ | DS1 2 ² | DS1 2 ¹ | DS1 2 ⁰ |
| AD1 | DS2 dp | LEVEL HIGH | LEVEL LOW | RANGE AUTO | DS2 2 ³ | DS2 2 ² | DS2 2 ¹ | DS2 2 ⁰ |
| AD2 | DS3 dp | V | Hz | kHz | DS3 2 ³ | DS3 2 ² | DS3 2 ¹ | DS3 2 ⁰ |
| AD3 | DS4 dp | FINE | COARSE | SPOT | DS4 2 ³ | DS4 2 ² | DS4 2 ¹ | DS4 2 ⁰ |
| AD4 | DS5 dp | DEG | Q (unit) | D (unit) | DS5 2 ³ | DS5 2 ² | DS5 2 ¹ | DS5 2 ⁰ |
| AD5 | M Ω (disp B) | k Ω (disp B) | Ω (disp B) | m Ω (disp B) | DS6 2 ³ | DS6 2 ² | DS6 2 ¹ | DS6 2 ⁰ |
| AD6 | DS7 dp | Z | C | L | DS7 2 ³ | DS7 2 ² | DS7 2 ¹ | DS7 2 ⁰ |
| AD7 | DS8 dp | G/ESR | Q (FUNC) | D (FUNC) | DS8 2 ³ | DS8 2 ² | DS8 2 ¹ | DS8 2 ⁰ |
| AD8 | DS9 dp | | | CKT AUTO | DS9 2 ³ | DS9 2 ² | DS9 2 ¹ | DS9 2 ⁰ |
| AD9 | DS10 dp | MEAS FAST | MEAS MED | MEAS SLOW | DS10 2 ³ | DS10 2 ² | DS10 2 ¹ | DS10 2 ⁰ |
| AD10 | kH | H | mH | μ H | DS11 2 ³ | DS11 2 ² | DS11 2 ¹ | DS11 2 ⁰ |
| AD11 | DS12 dp | L ONLY | TRIG HOLD | TRIG INT | DS12 2 ³ | DS12 2 ² | DS12 2 ¹ | DS12 2 ⁰ |
| AD12 | DS13 dp | C ONLY | BIAS | FREQ | DS13 2 ³ | DS13 2 ² | DS13 2 ¹ | DS13 2 ⁰ |
| AD13 | DS14 dp | Δ | TRIG LAMP | SELF TEST | DS14 2 ³ | DS14 2 ² | DS14 2 ¹ | DS14 2 ⁰ |
| AD14 | | S | mS | μ S | | | | |
| AD15 | M Ω (disp A) | k Ω (disp A) | Ω (disp A) | m Ω (disp A) | REMOTE | SRQ | TALK | LISTEN |

DC BIAS Flow Diagram

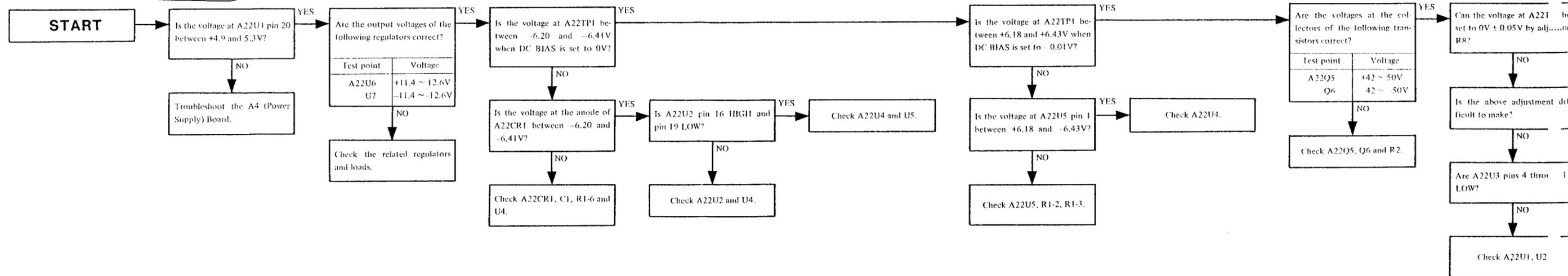


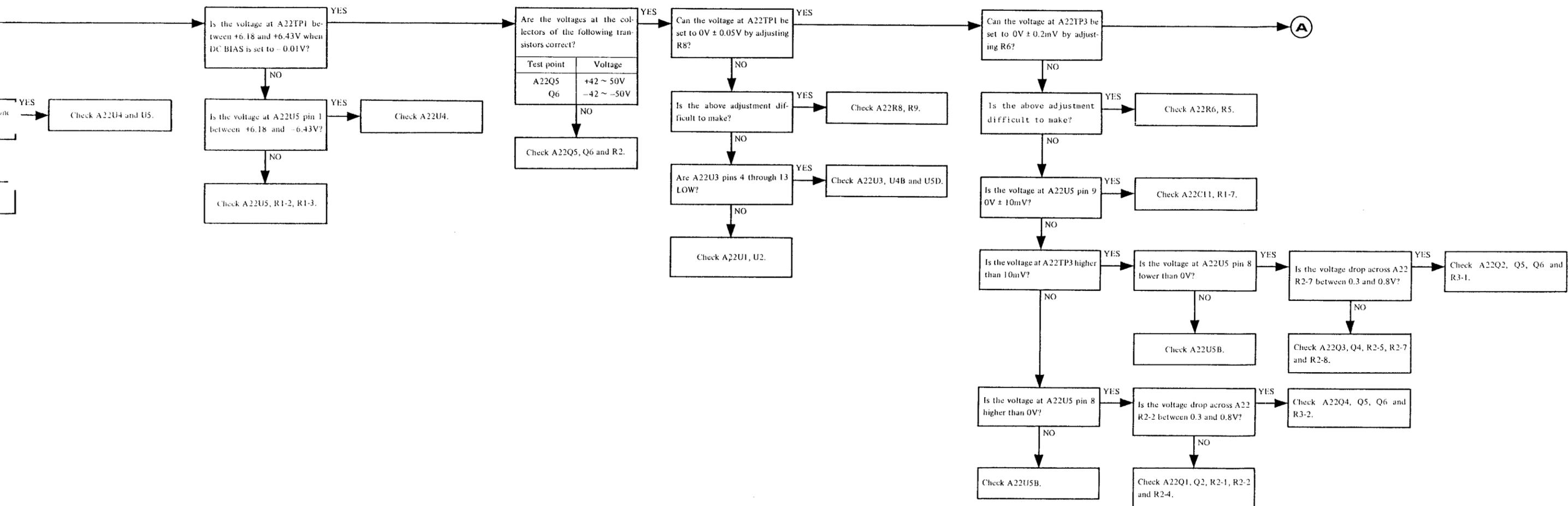
m

panel controls as
 C-D
 1nF fixed
 1 kHz
 LOW
 EXT
 terminals.

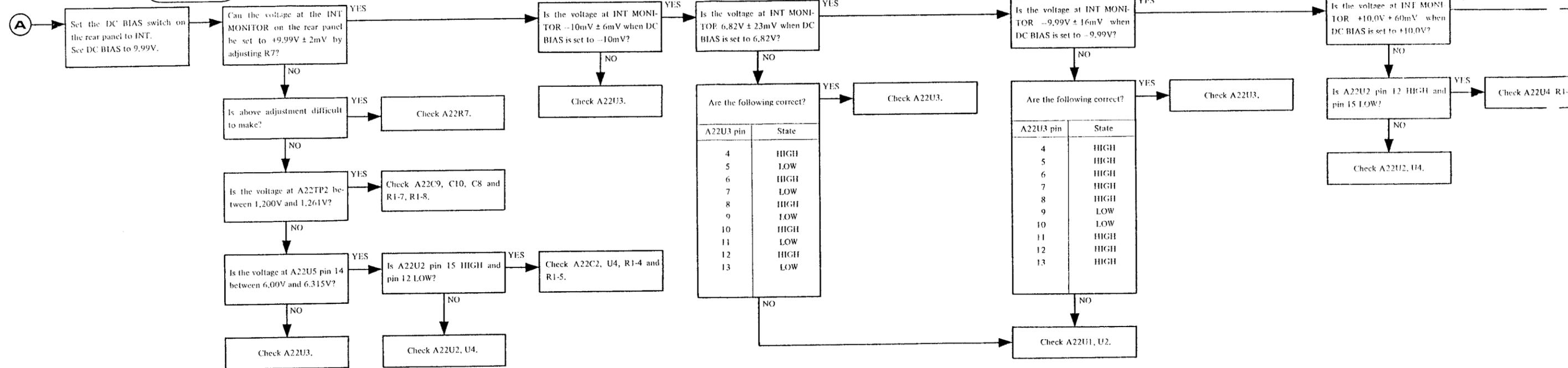


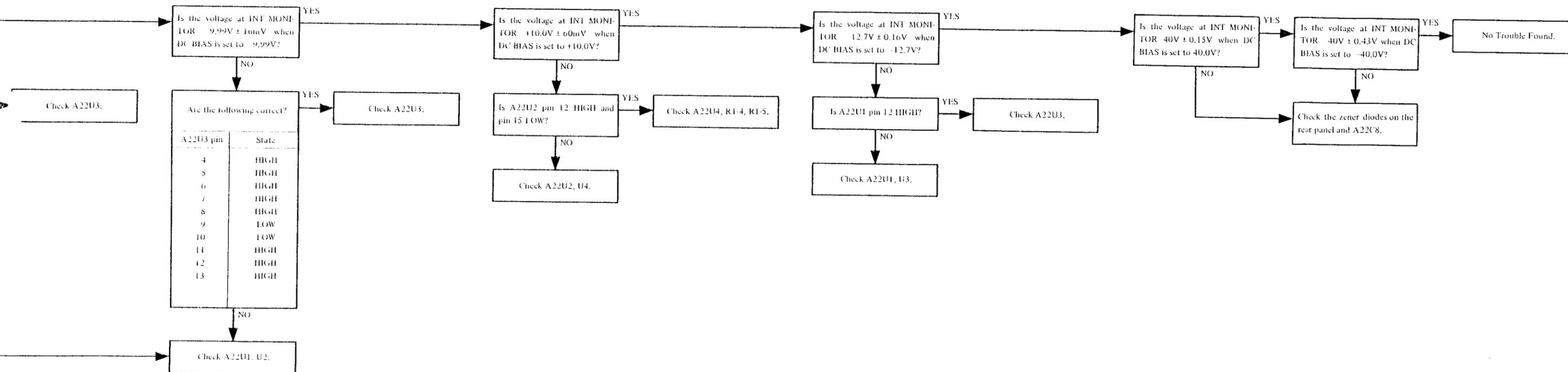
Flow Diagram **A22 - 1**





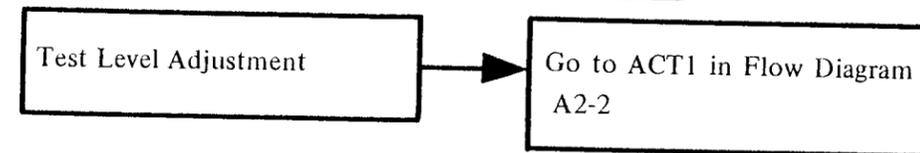
Flow Diagram **A22 - 1**





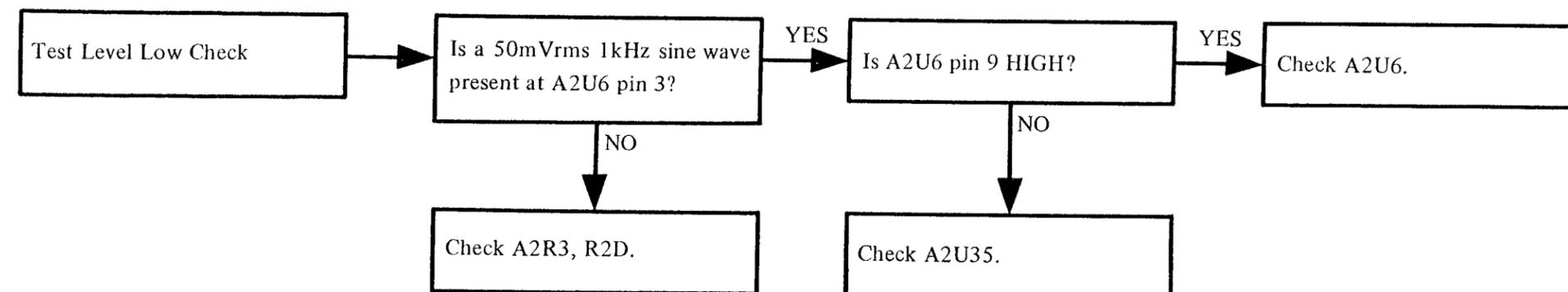
Flow Diagram

ADJ-1



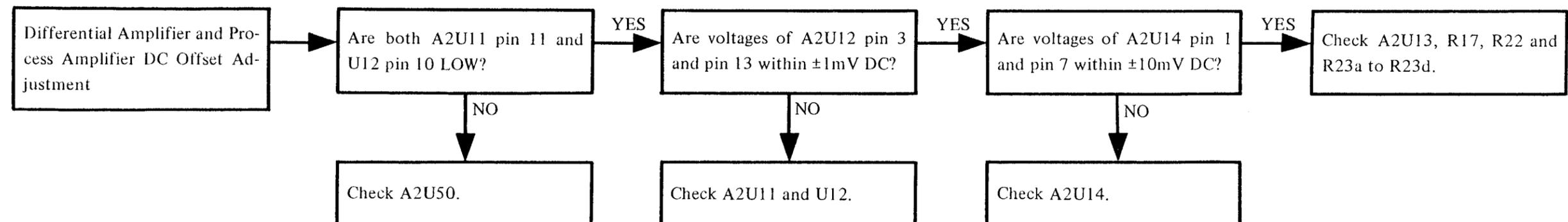
Flow Diagram

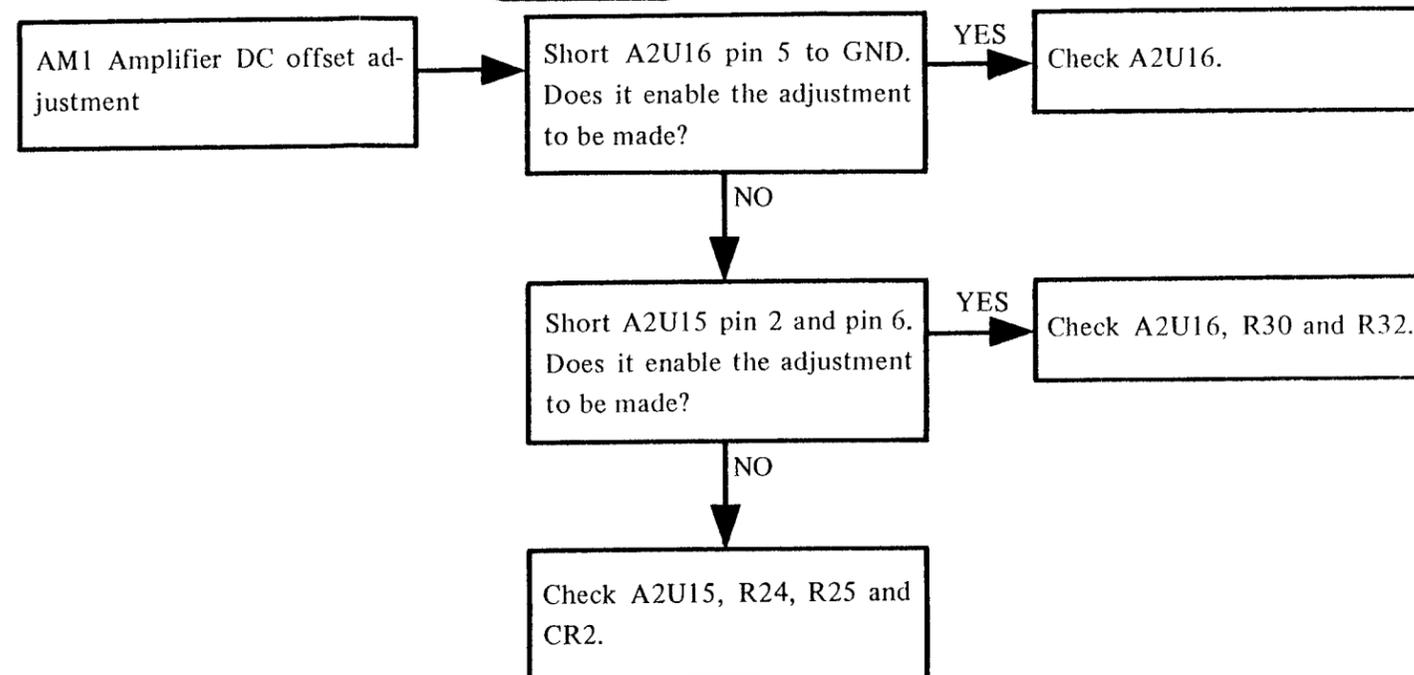
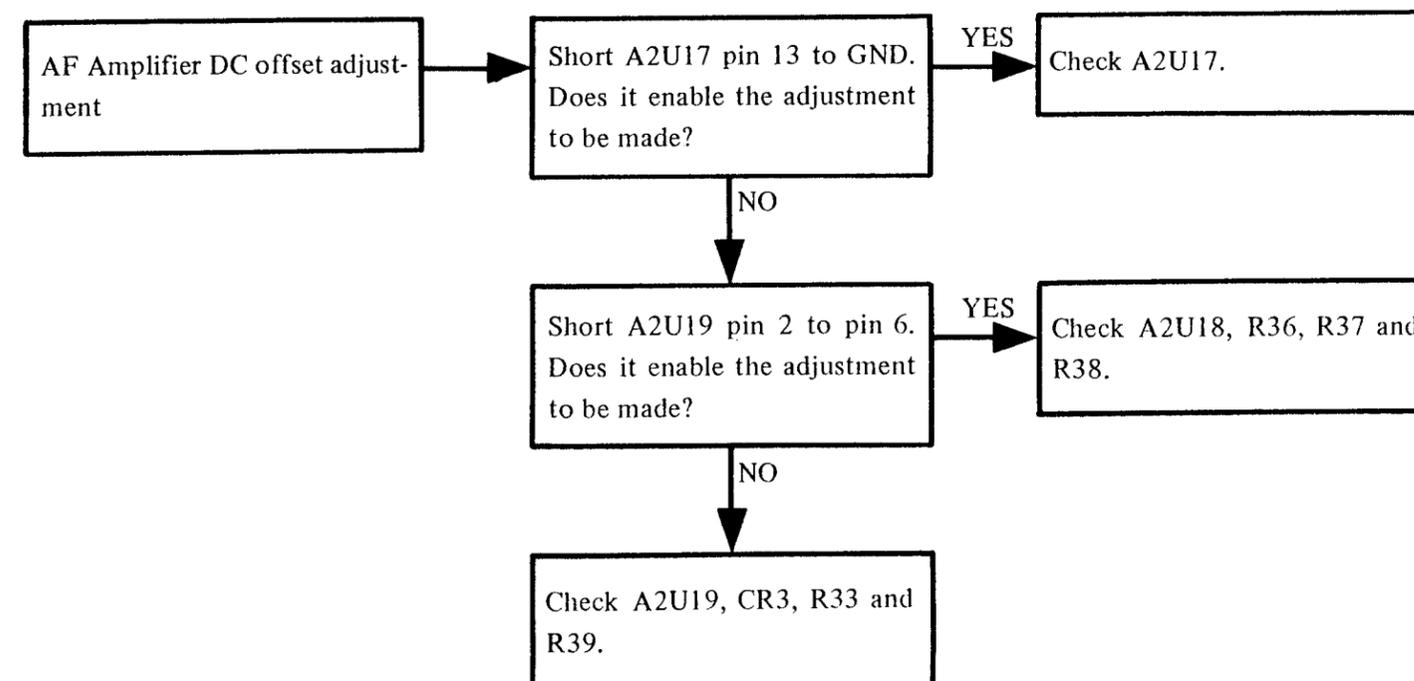
ADJ-2



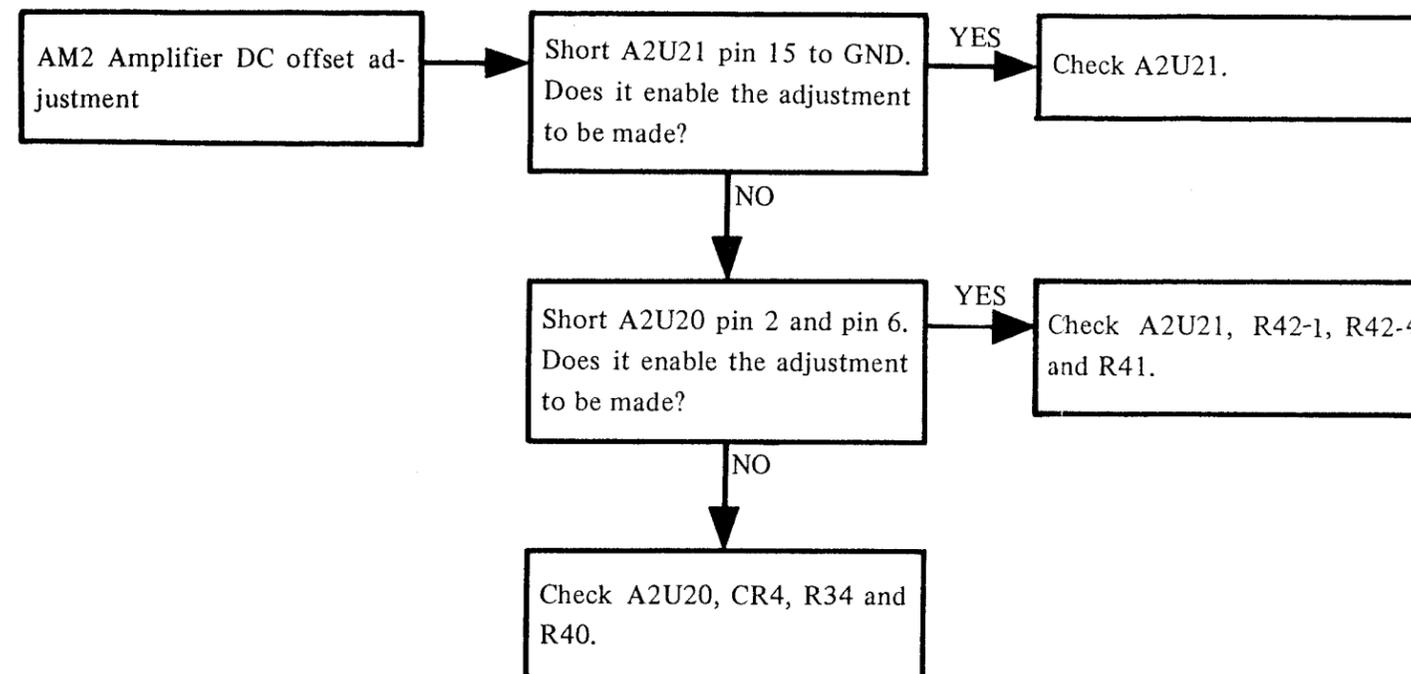
Flow Diagram

ADJ-3

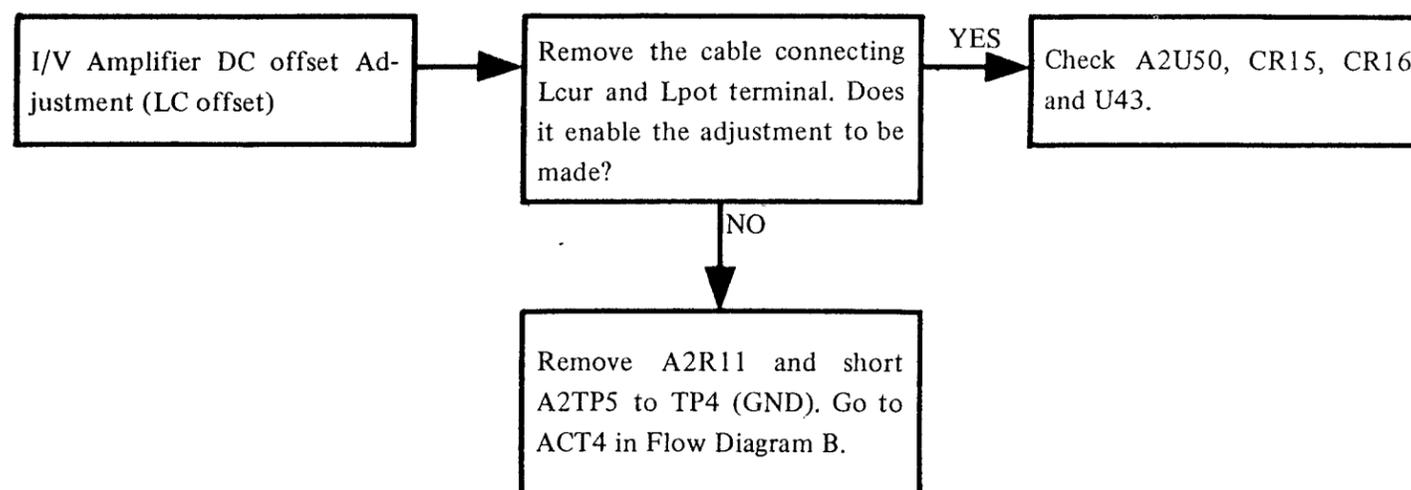


Flow Diagram ADJ-4**Flow Diagram ADJ-5**

Flow Diagram **ADJ-6**

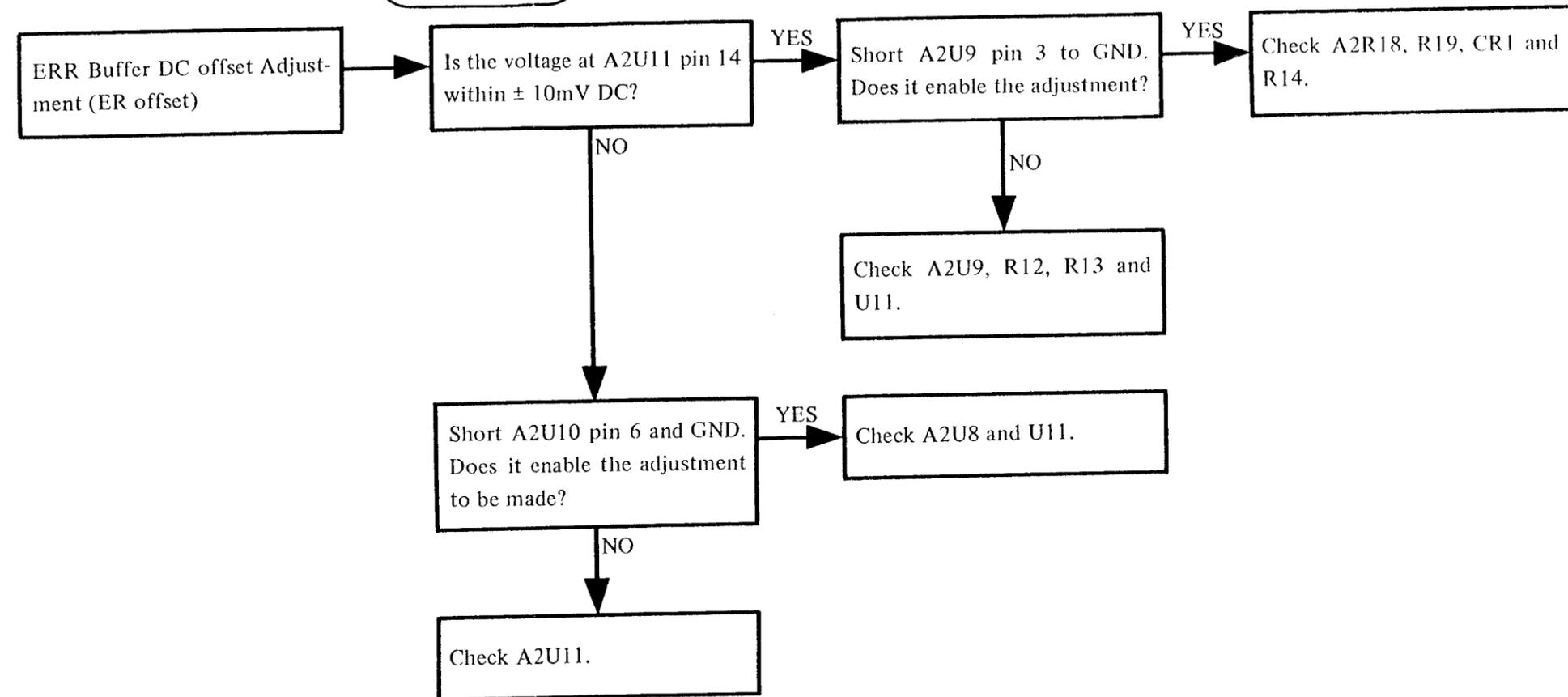


Flow Diagram **ADJ-7**

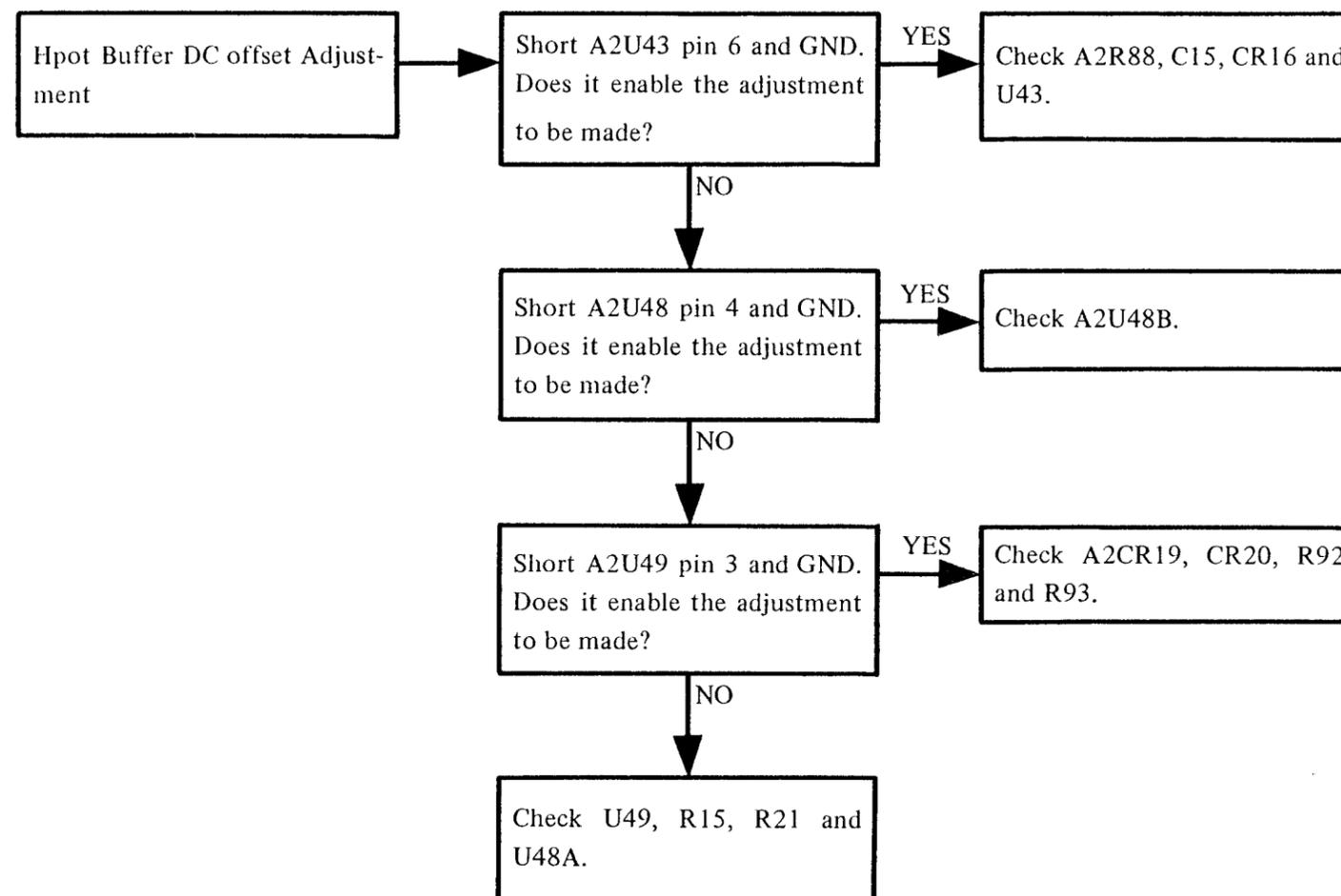


Flow Diagram

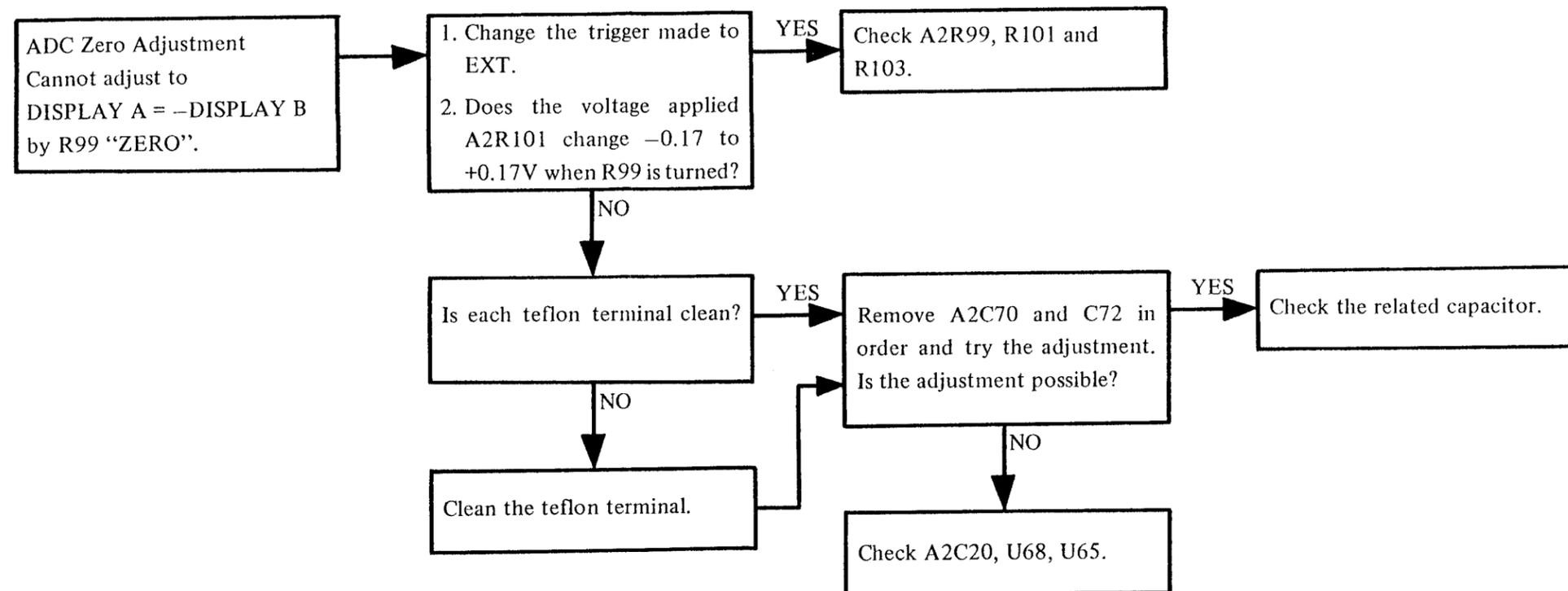
ADJ-8



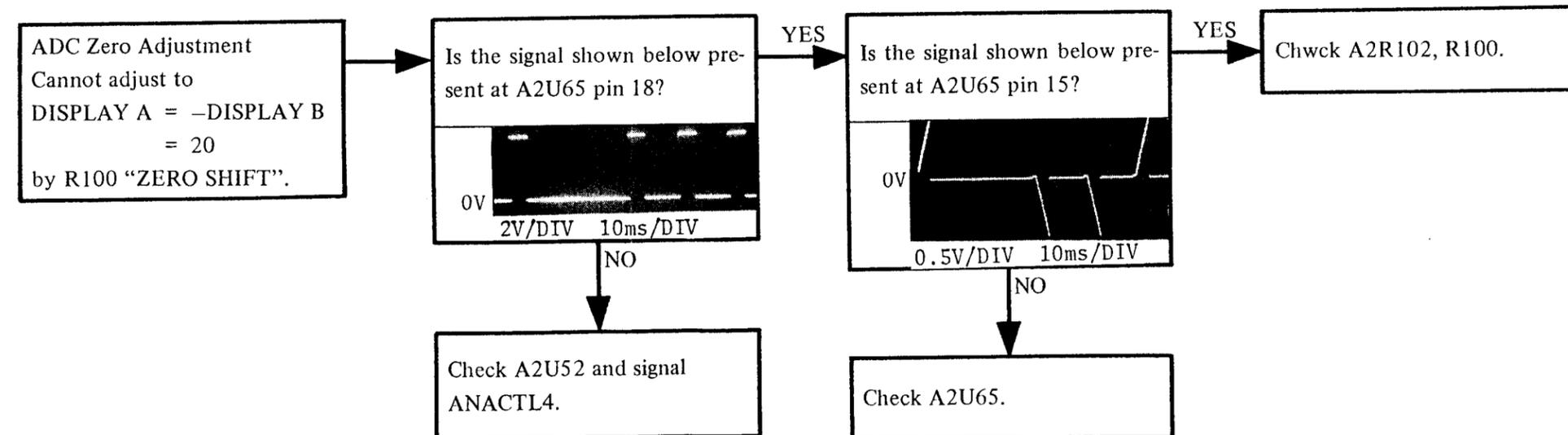
Flow Diagram **ADJ-9**



Flow Diagram **ADJ-10**

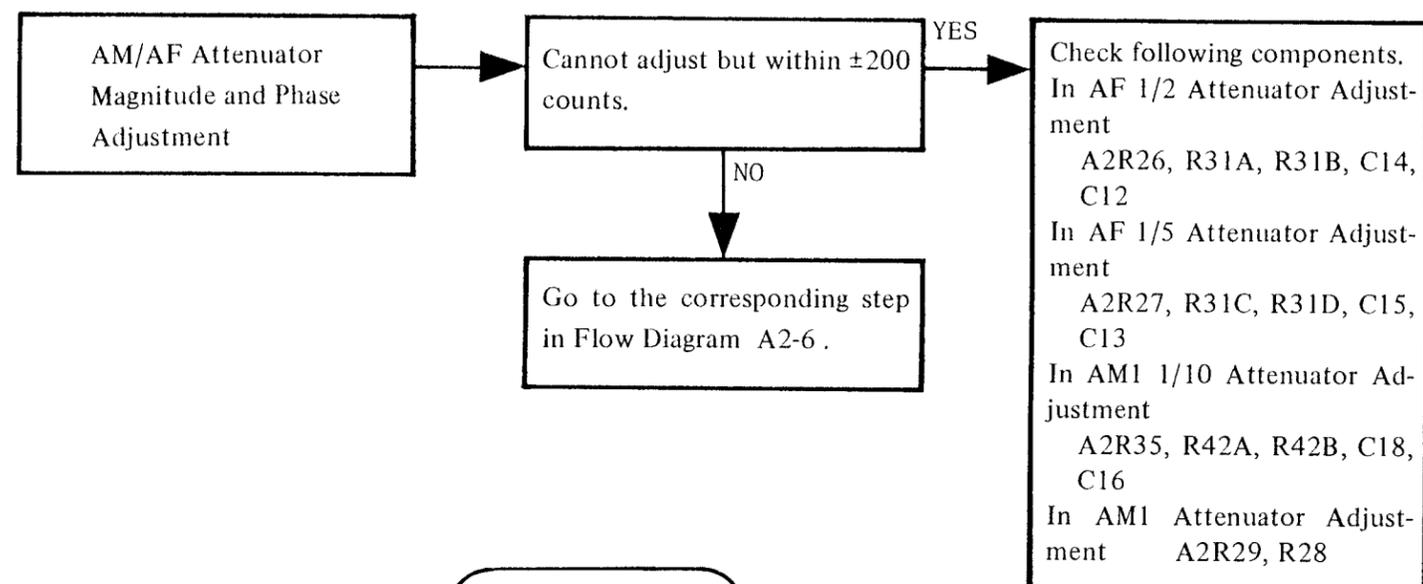


Flow Diagram **ADJ-11**



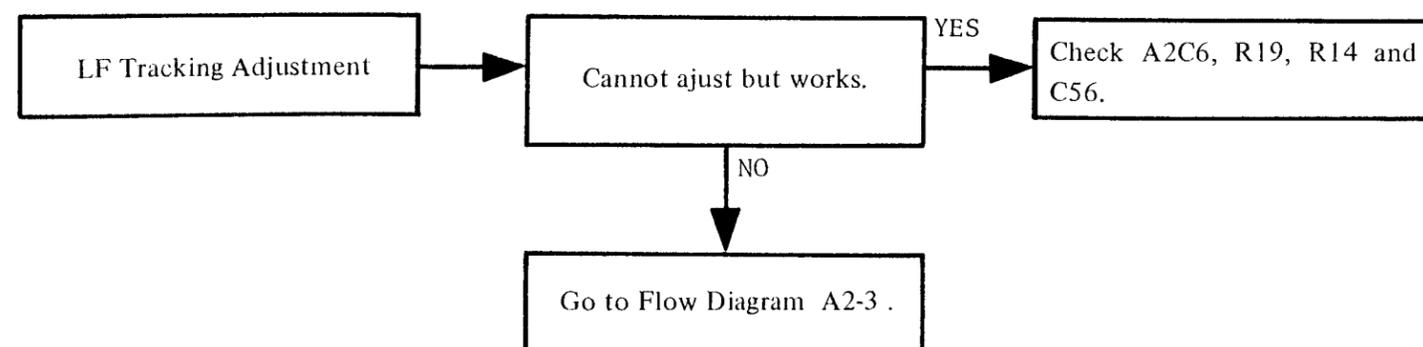
Flow Diagram

ADJ-12

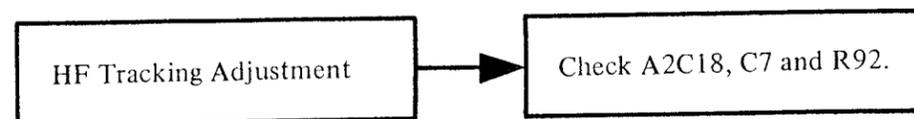


Flow Diagram

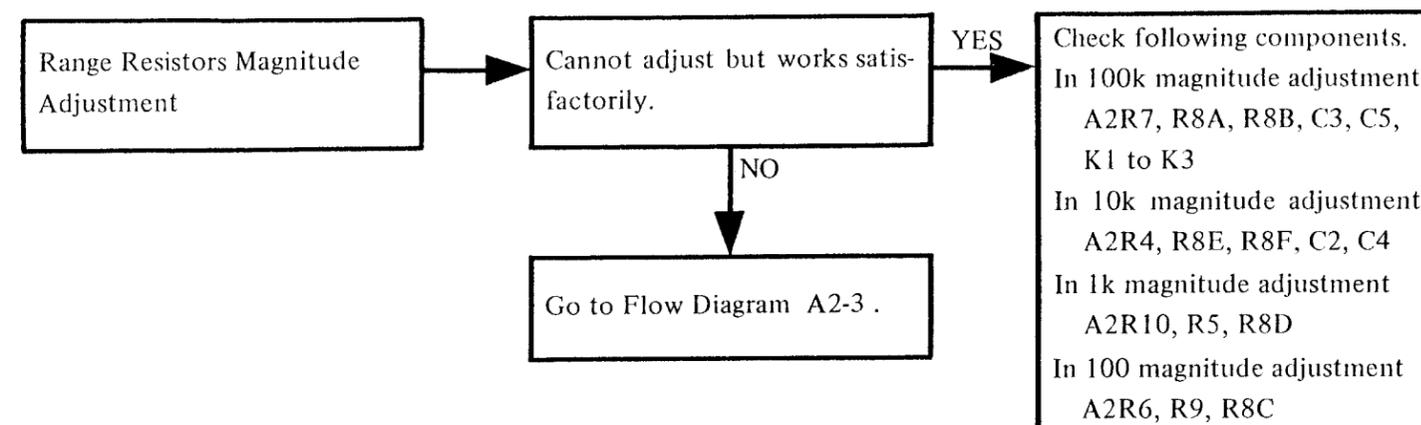
ADJ-13



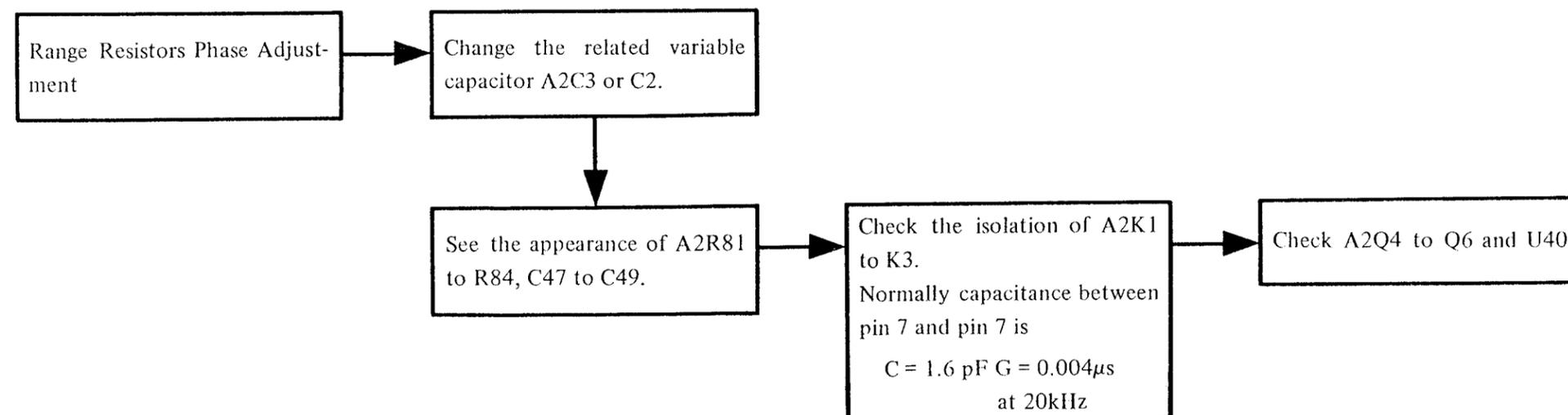
Flow Diagram **ADJ-14**



Flow Diagram **ADJ-15**



Flow Diagram **ADJ-16**



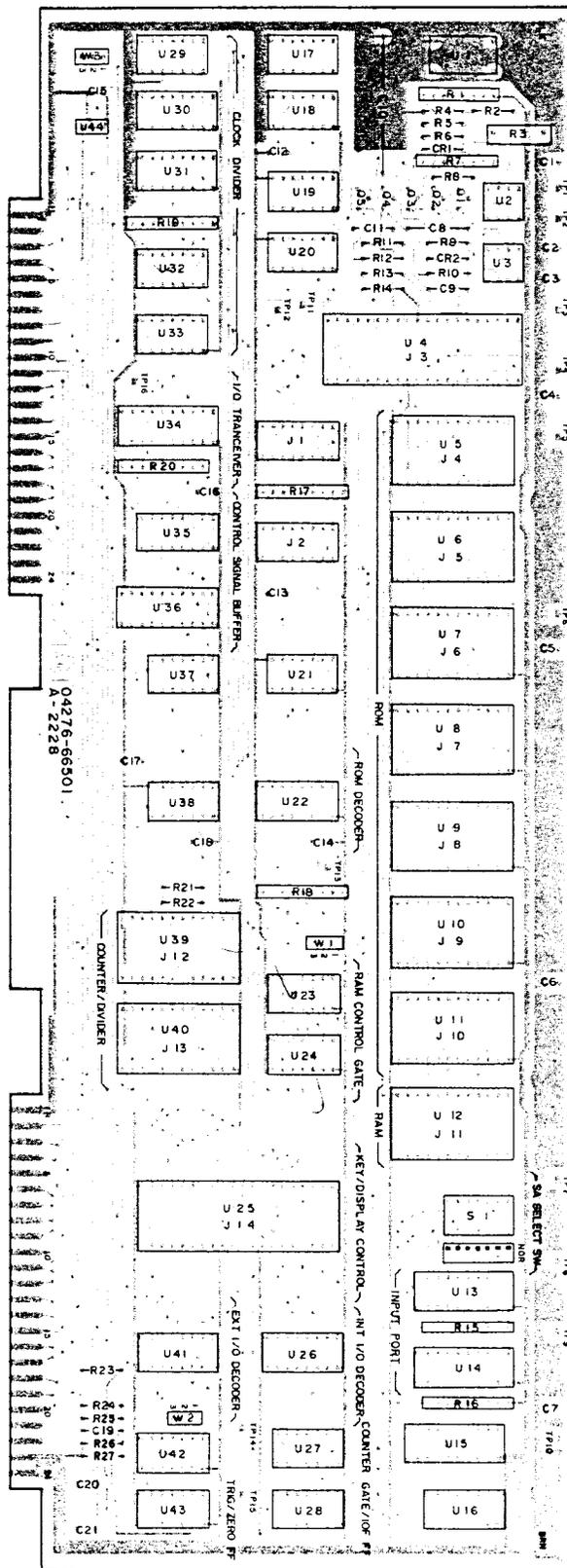
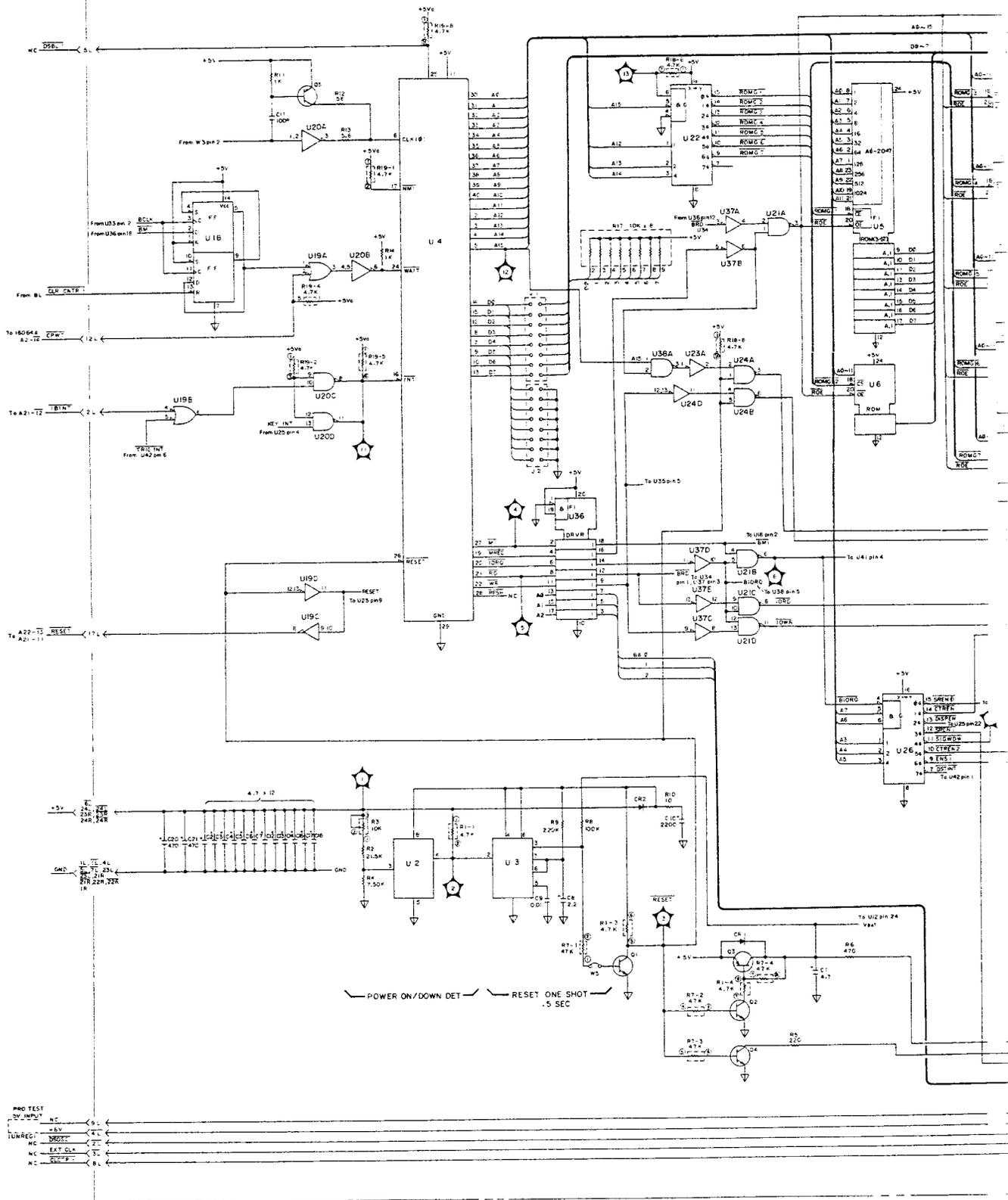
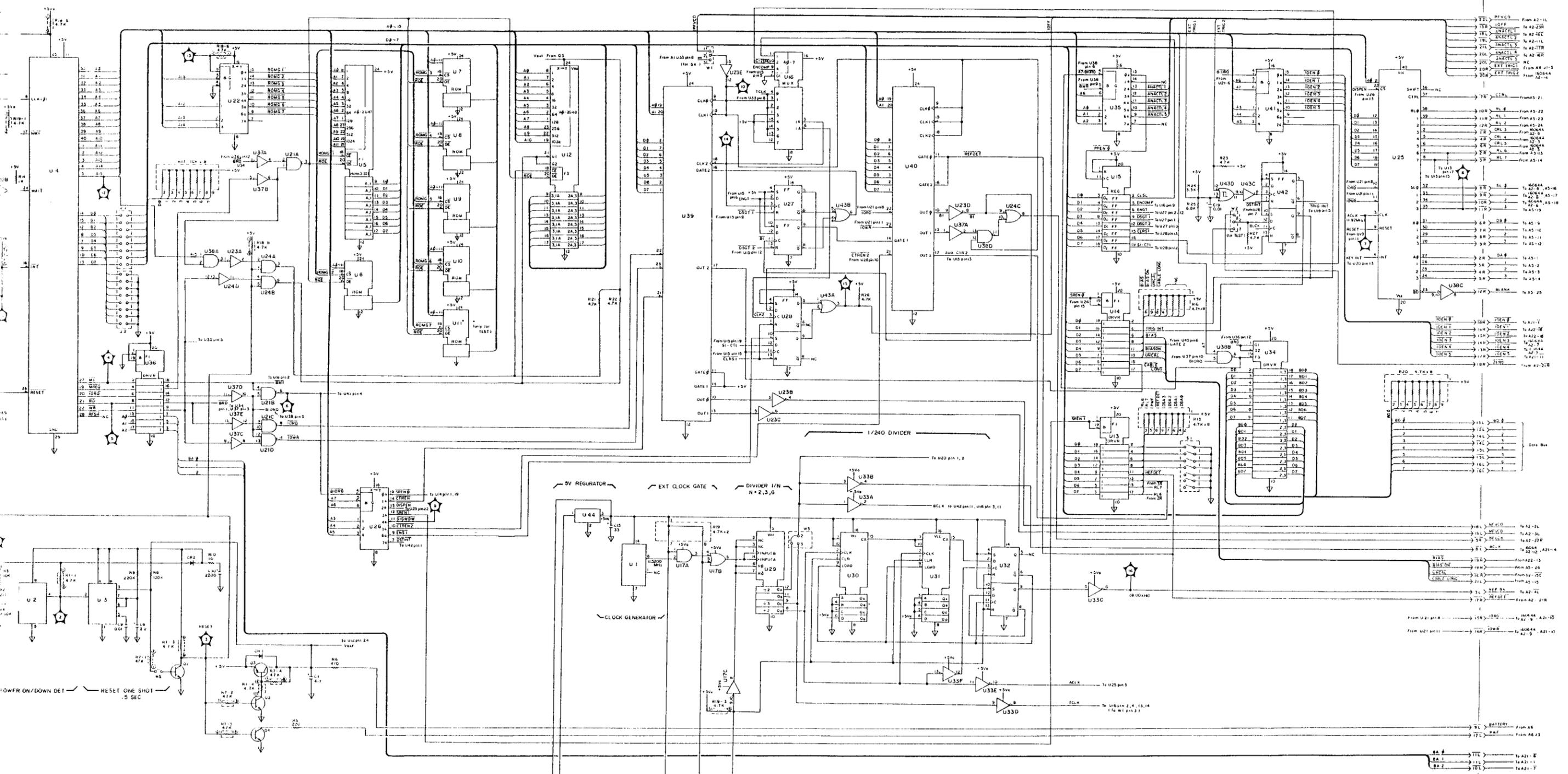


Figure 8-XX. A1 LOGIC Board Assembly Component Locations.

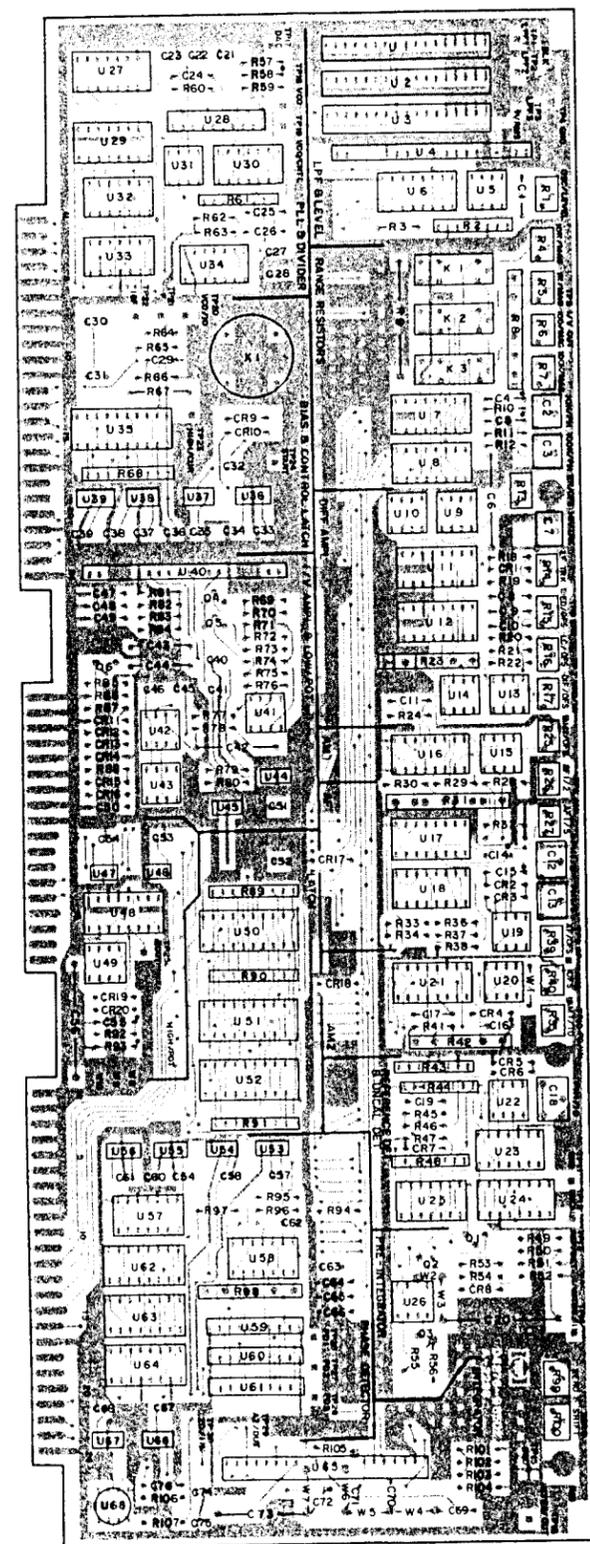
AI LOGIC (P/N: 04276-66501)



501)



- NOTES:
1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
 2. UNLESS OTHERWISE INDICATED:
RESISTANCE IN OHMS (Ω)
CAPACITANCE IN MICROFARADS (μF)
INDUCTANCE IN MICROHENRIES (μH)



A2 ANALOG (P/N:04276-66502) 1 of 2

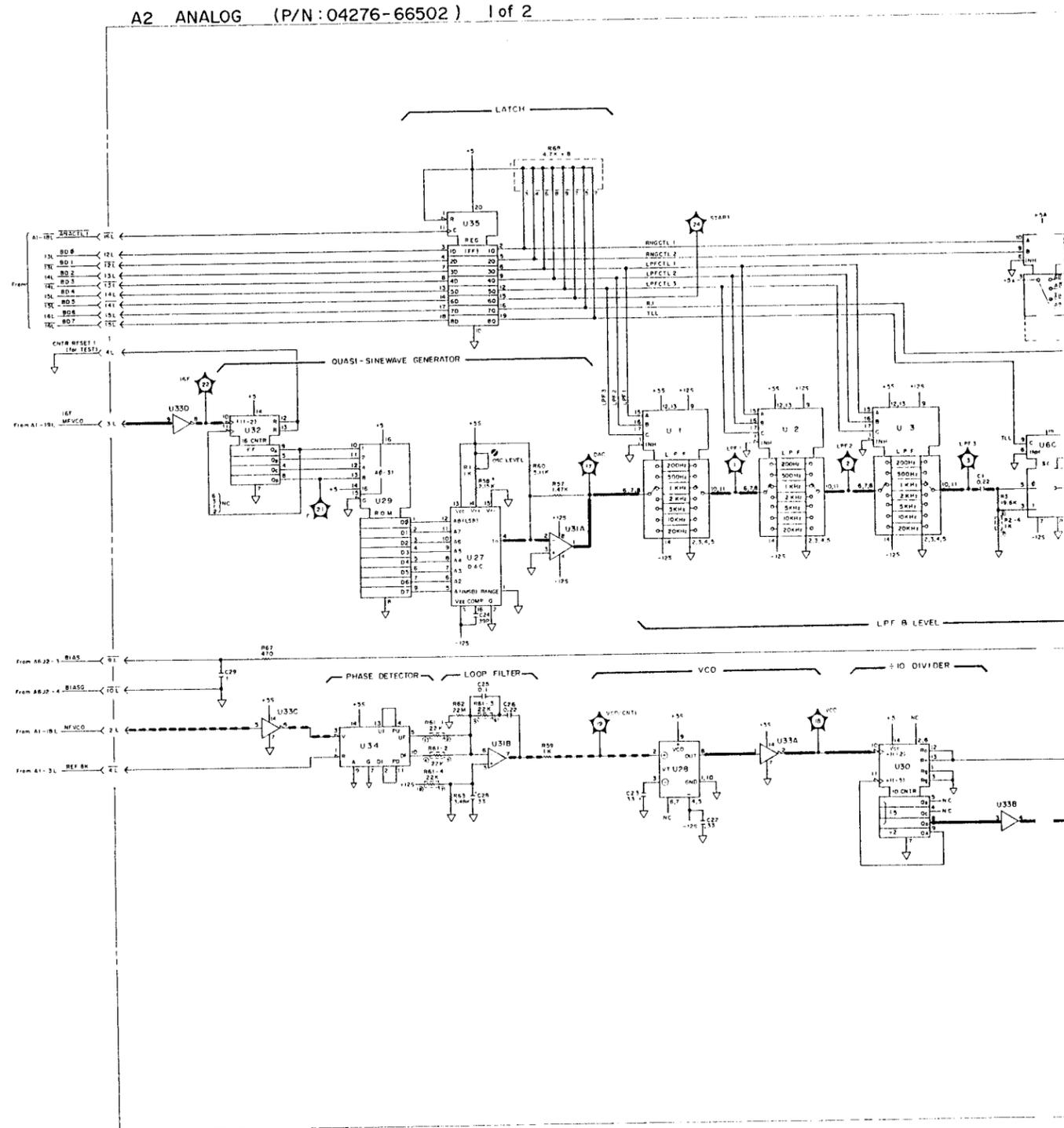
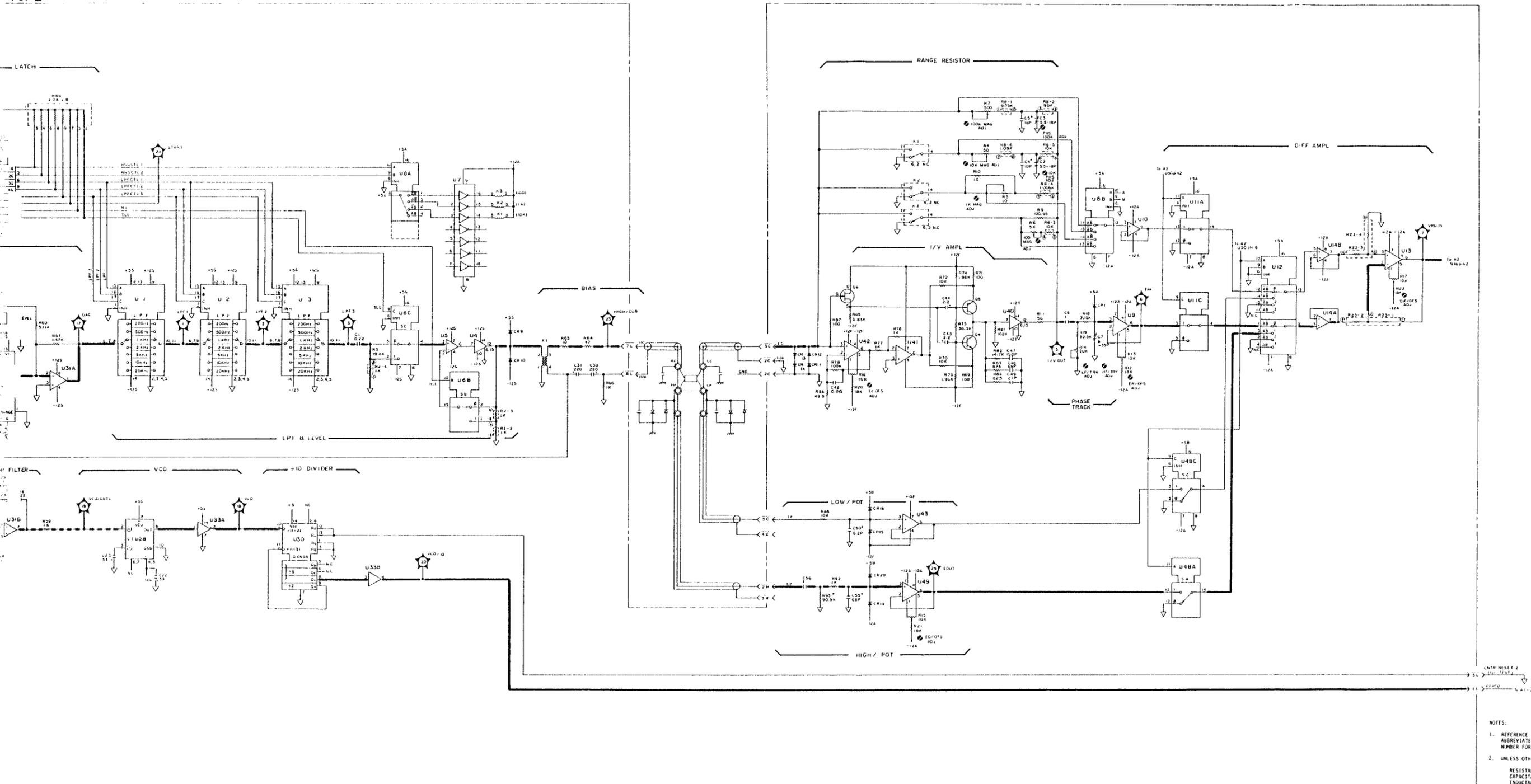
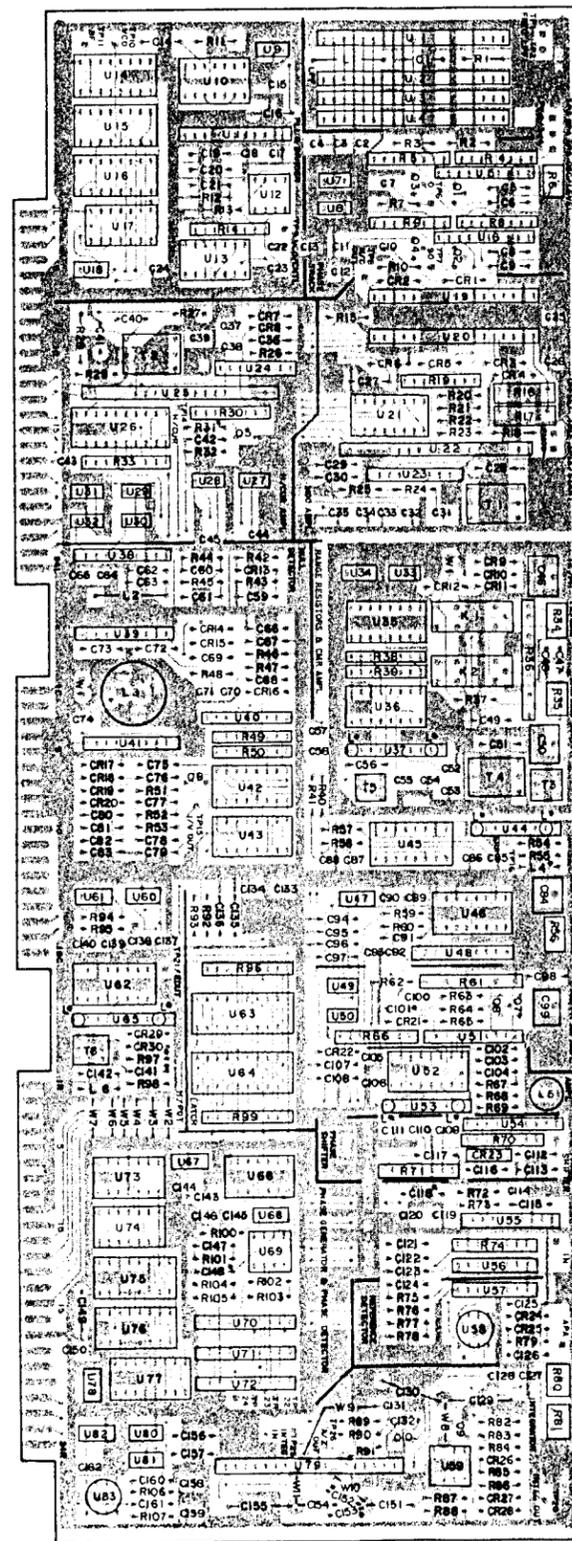


Figure 8-XX. A2 ANALOG Board Assembly Component Locations.



LATCH RESET 2
 5C
 11
 12

- NOTES:
1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
 2. UNLESS OTHERWISE INDICATED:
 RESISTANCE IN OHMS (Ω)
 CAPACITANCE IN MICROFARADS (μF)
 INDUCTANCE IN MICROHENRIES (μH)



A2 ANALOG (P/N : 04276 - 66502) 2 of 2

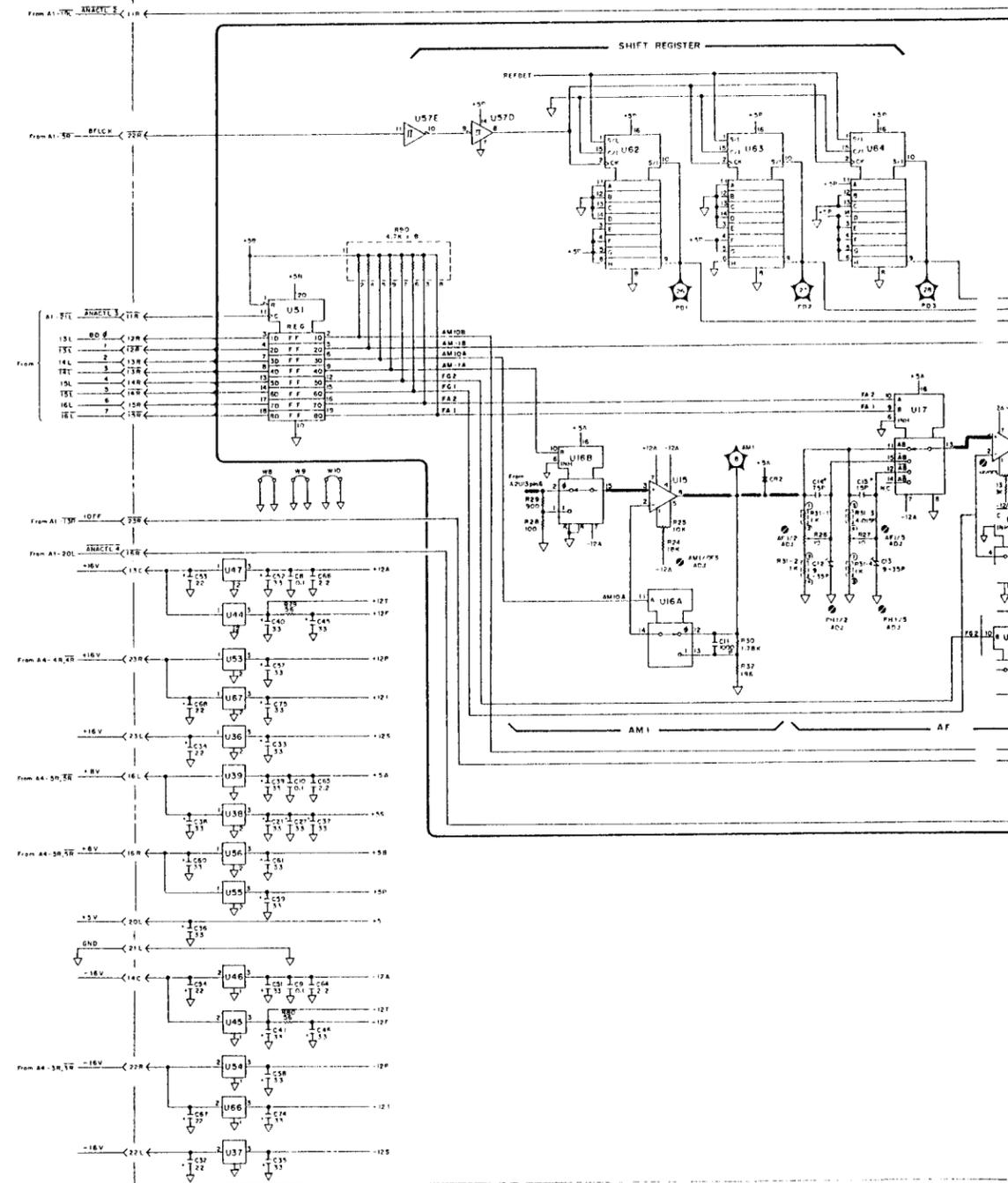
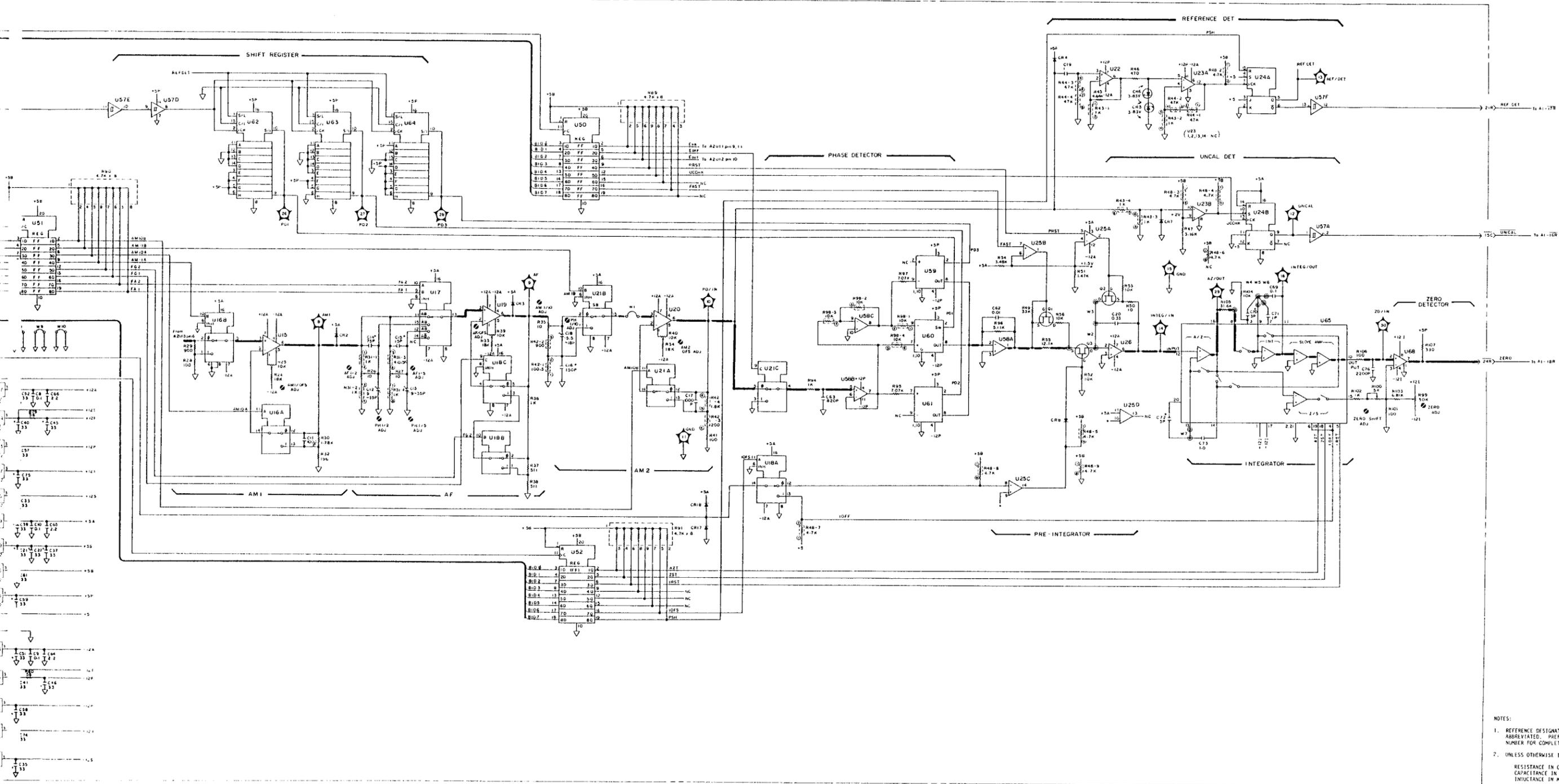


Figure 8-XX. A2 ANALOG Board Assembly Component Locations.



NOTES:
 1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
 2. UNLESS OTHERWISE INDICATED:
 RESISTANCE IN OHMS (Ω)
 CAPACITANCE IN MICROFARADS (μF)
 INDUCTANCE IN MICRORHENRIES (μH)

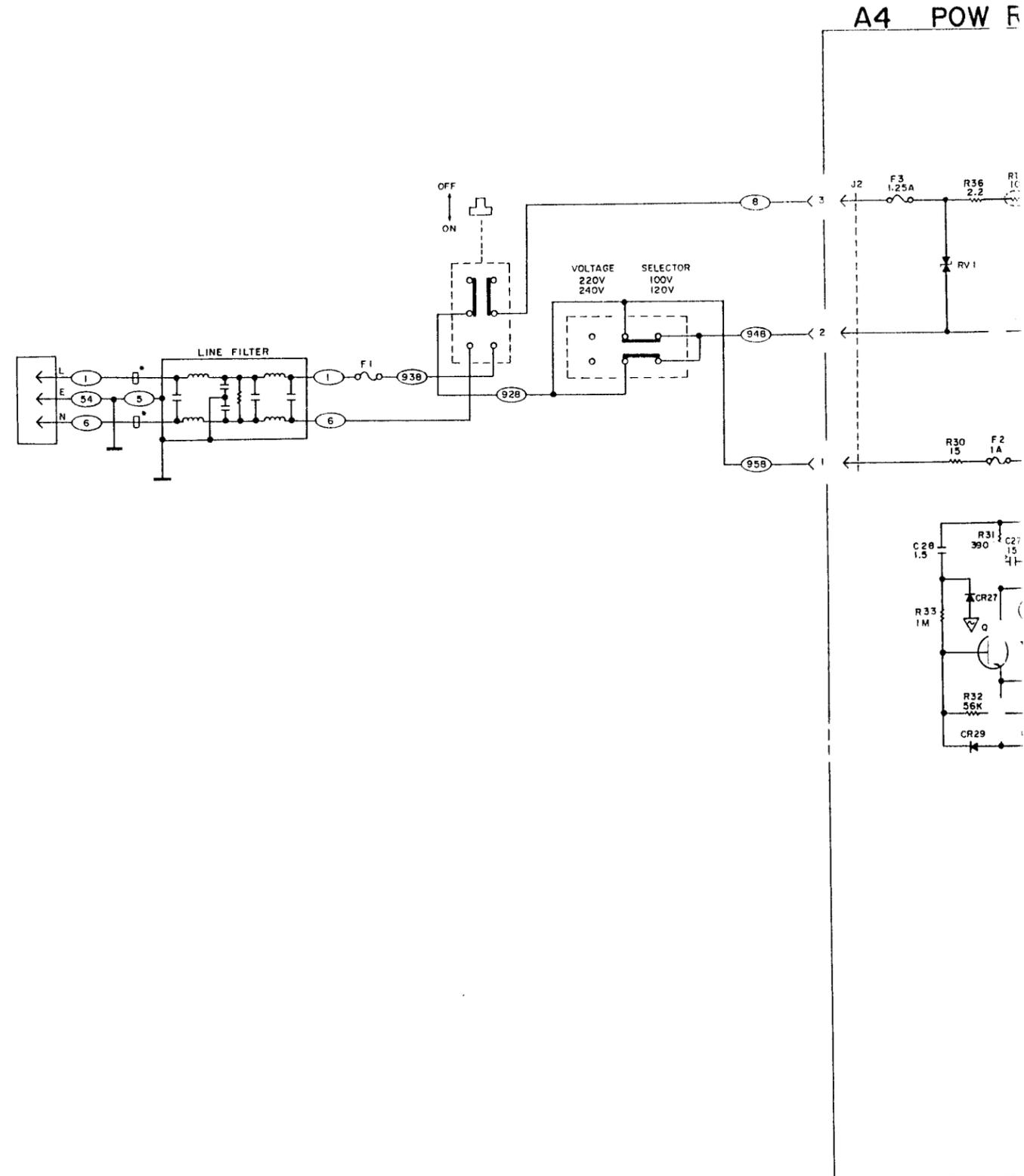
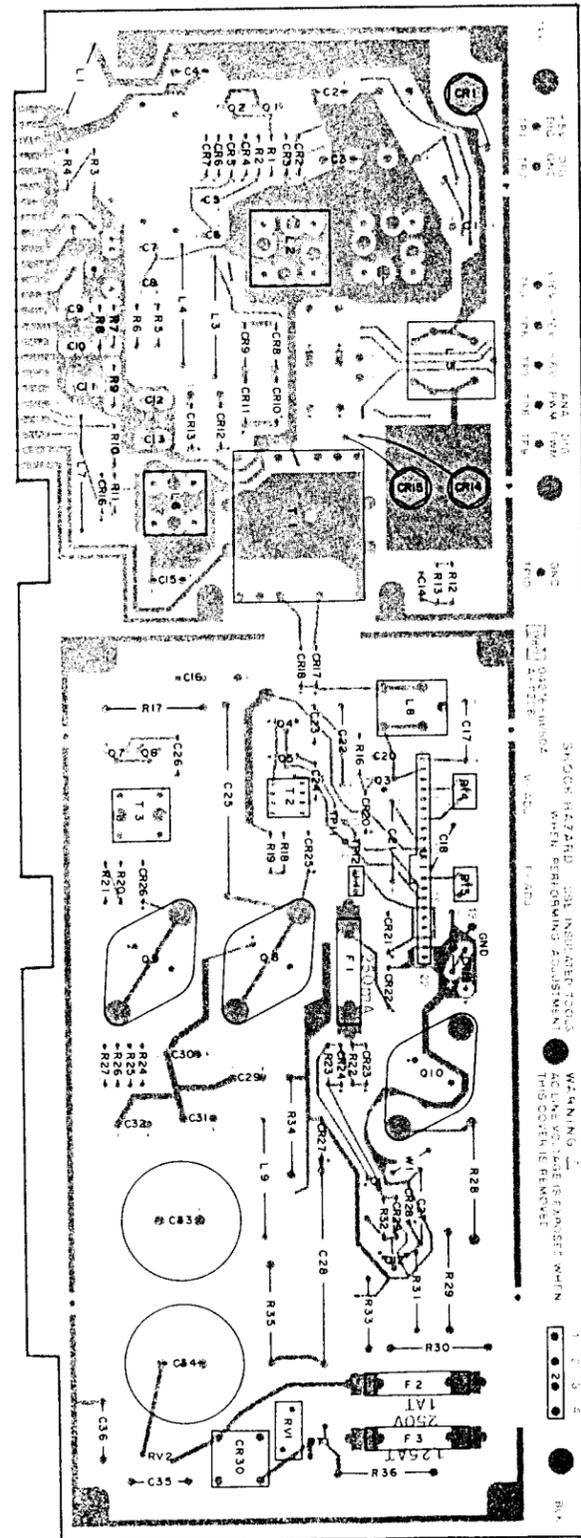
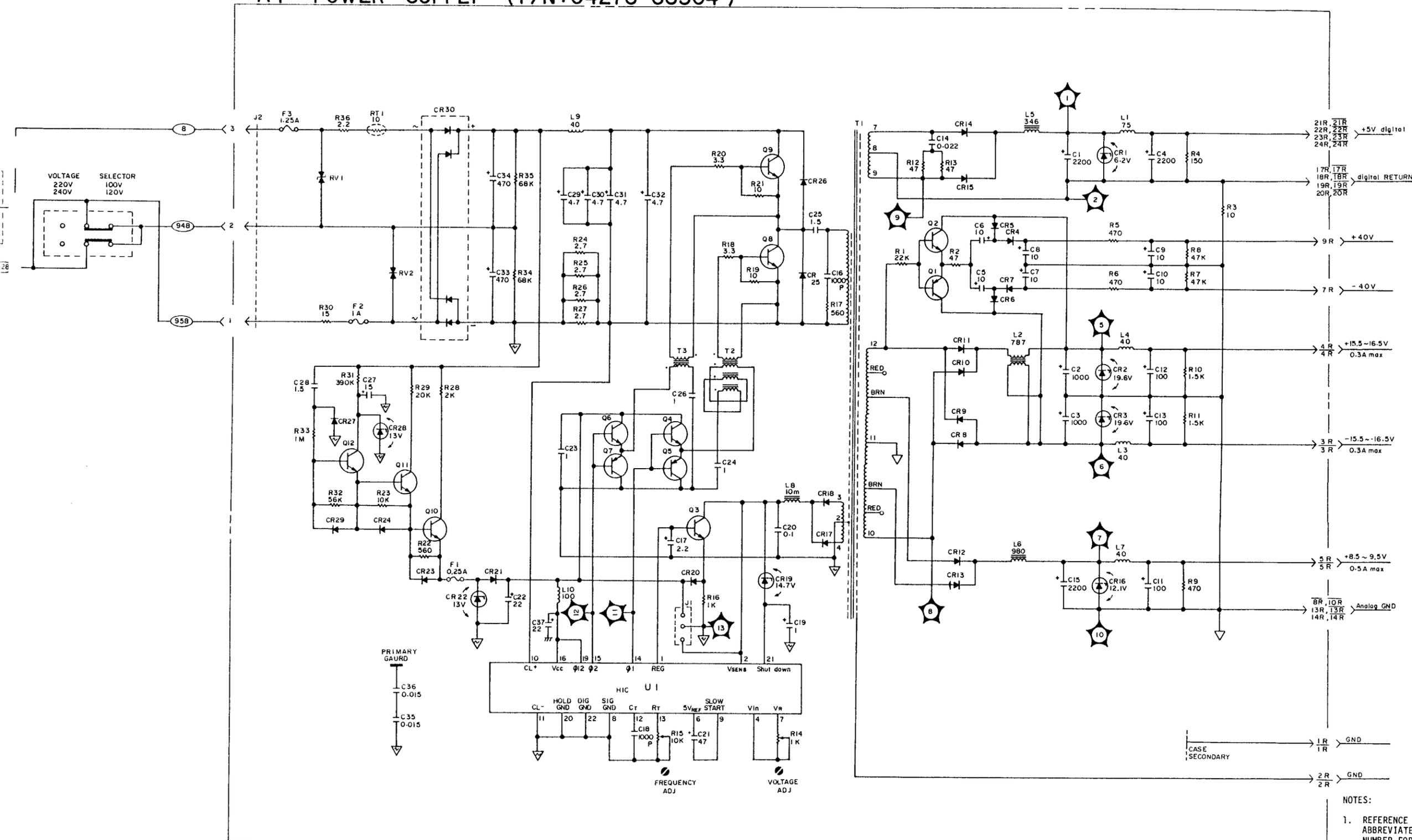
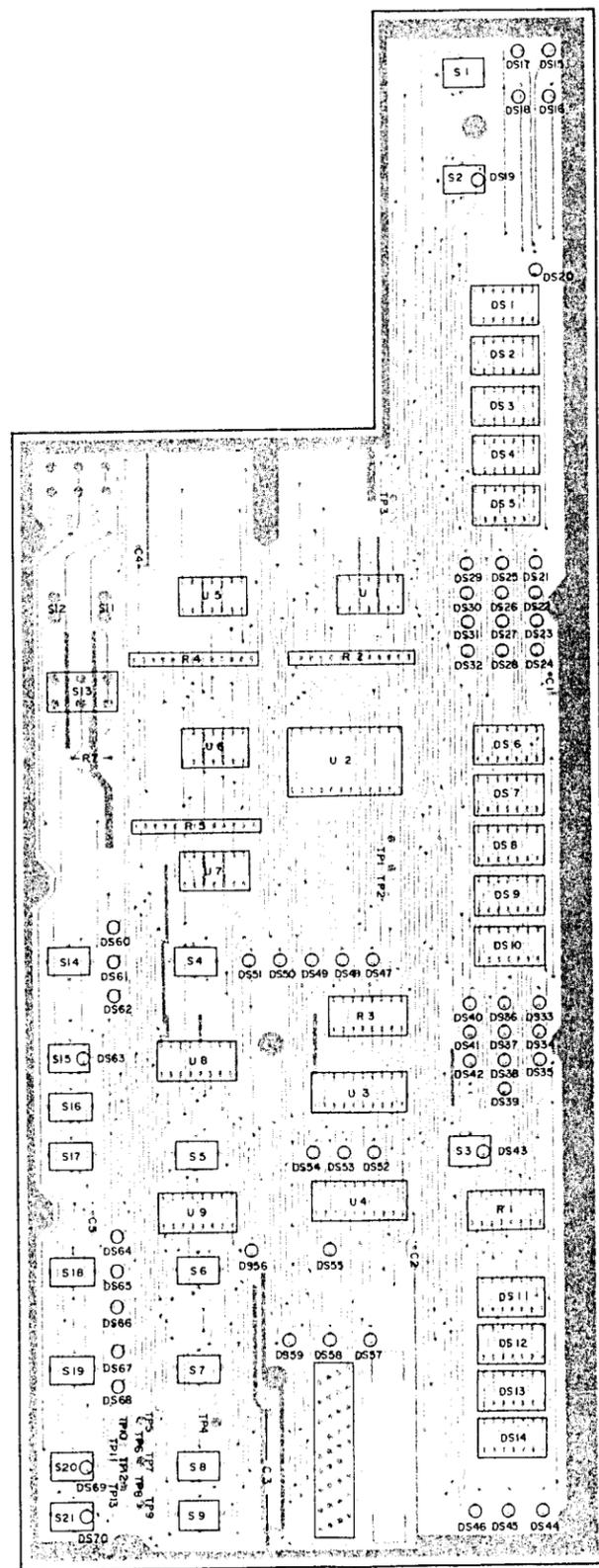


Figure 8-XX. A4 POWER SUPPLY Board Assembly Component Locations.

A4 POWER SUPPLY (P/N:04276-66504)



- NOTES:
1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
 2. UNLESS OTHERWISE INDICATED:
 RESISTANCE IN OHMS (Ω)
 CAPACITANCE IN MICROFARADS (μ F)
 INDUCTANCE IN MICROHENRIES (μ H)



A5 DISPLAY (P/N:04276-66505)

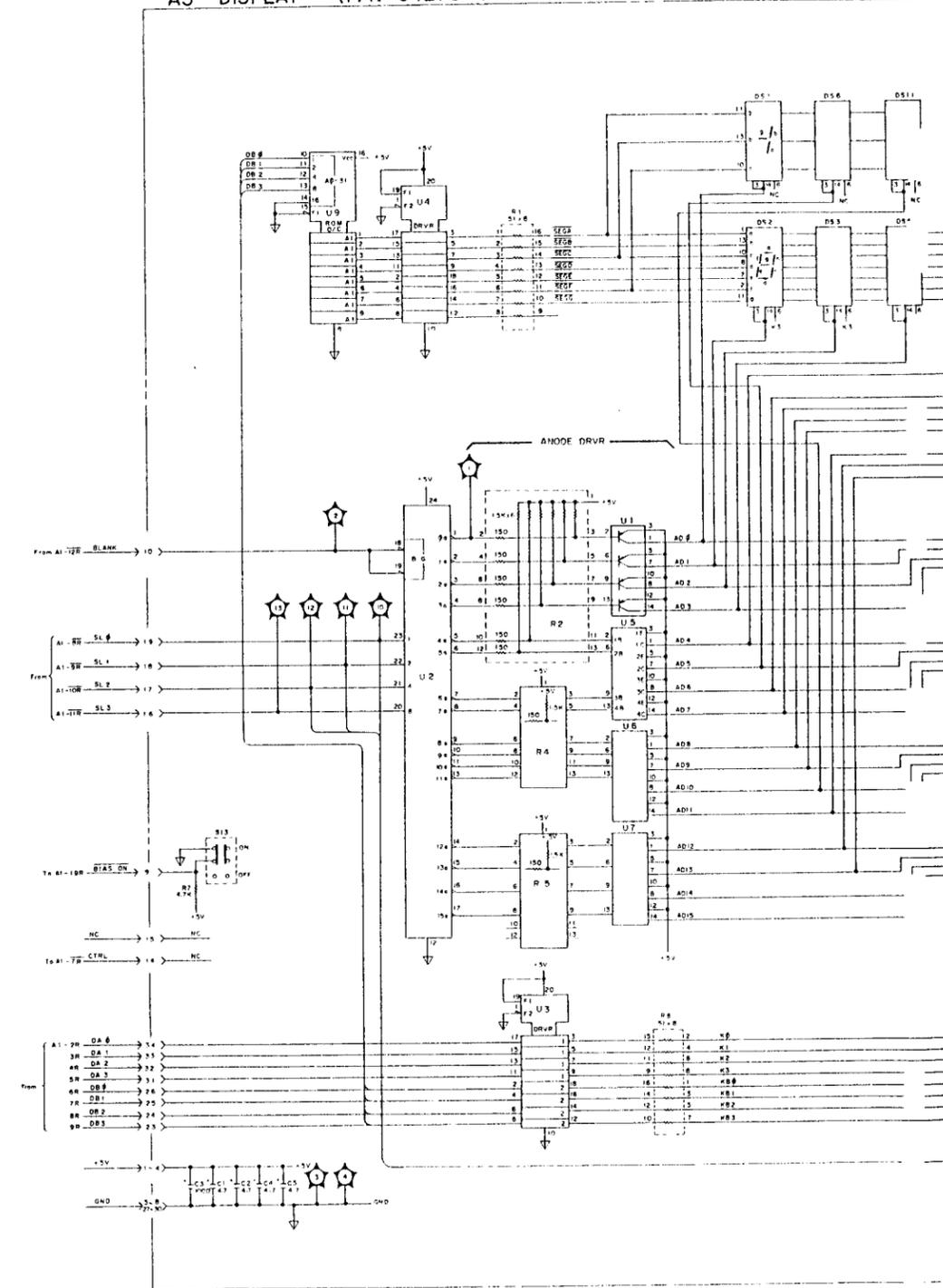
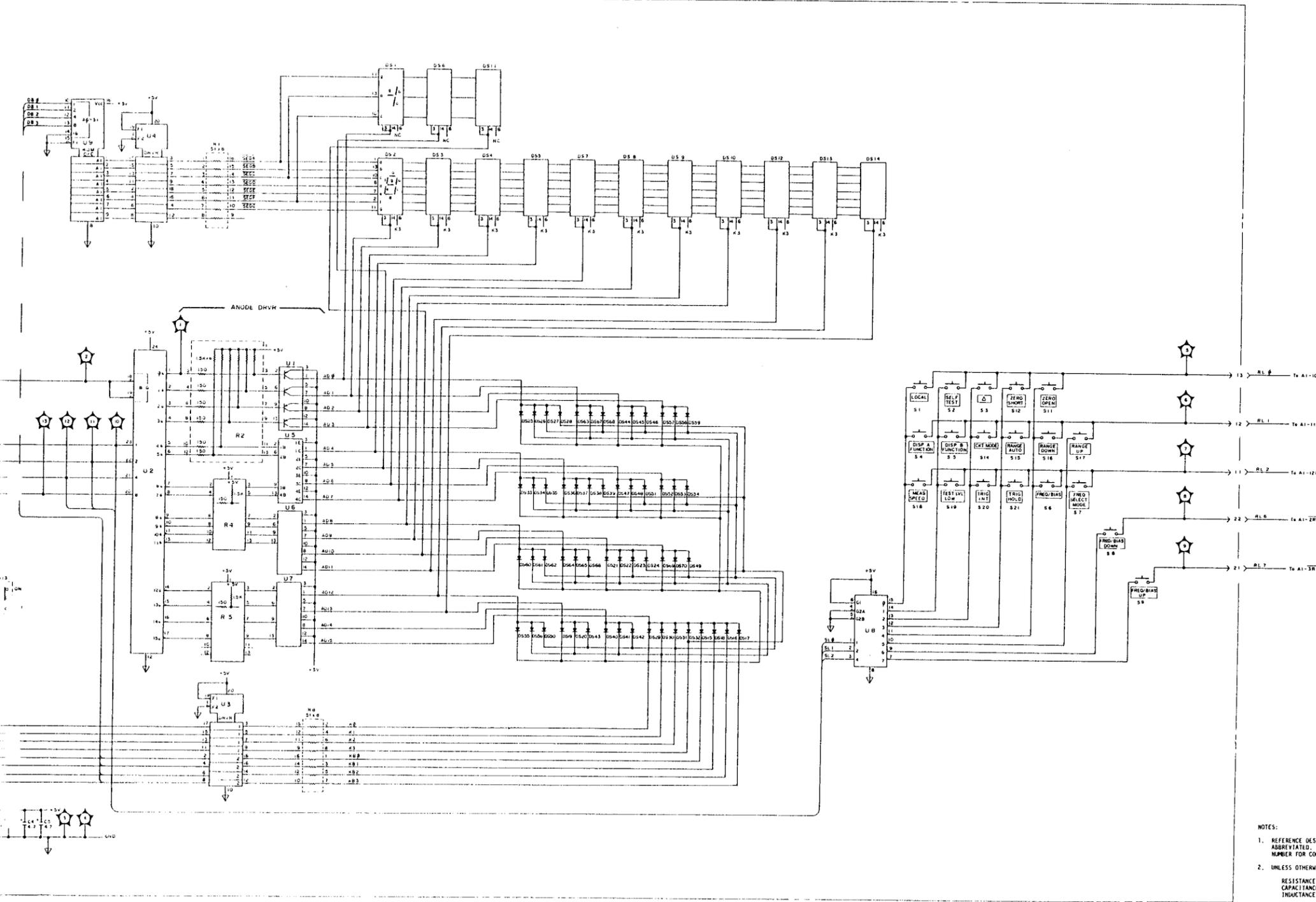


Figure 8-XX. A5 DISPLAY Board Assembly Component Locations.

DISPLAY (P/N : 04276-66505)



NOTES:
 1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
 2. UNLESS OTHERWISE INDICATED:
 RESISTANCE IN OHMS (Ω)
 CAPACITANCE IN MICROFARADS (μF)
 INDUCTANCE IN MICRORHENRIES (μH)

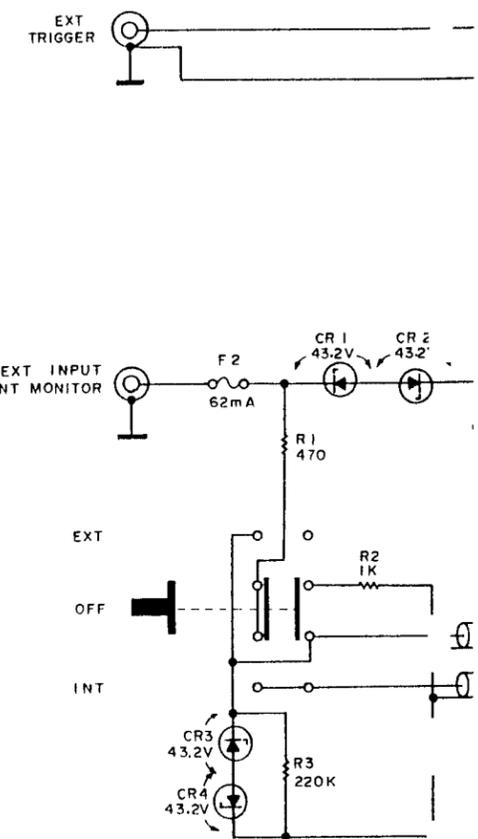
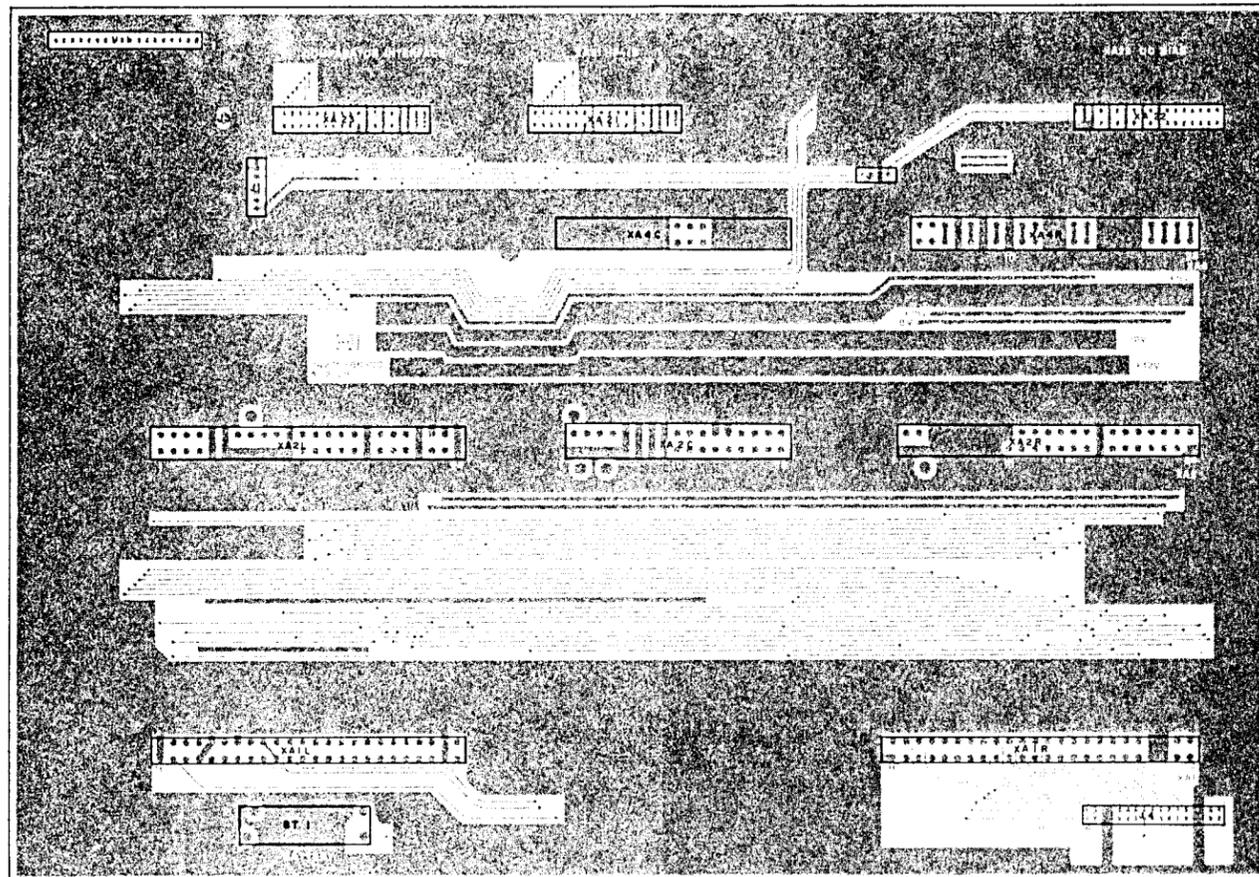
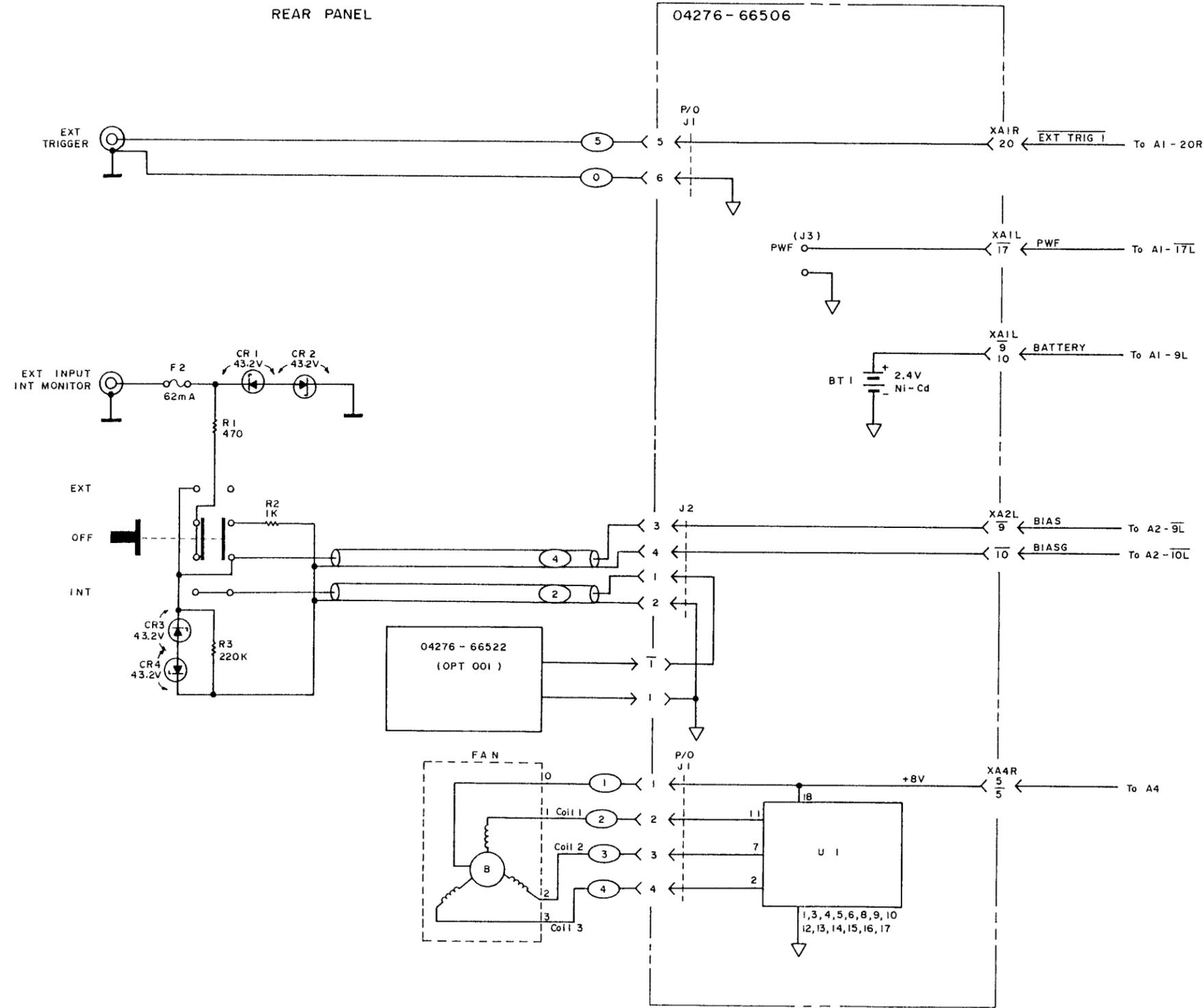


Figure 8-XX. A6 MOTHER Board Assembly Component Locations.

A6 MOTHER (P/N : 04276-66506)



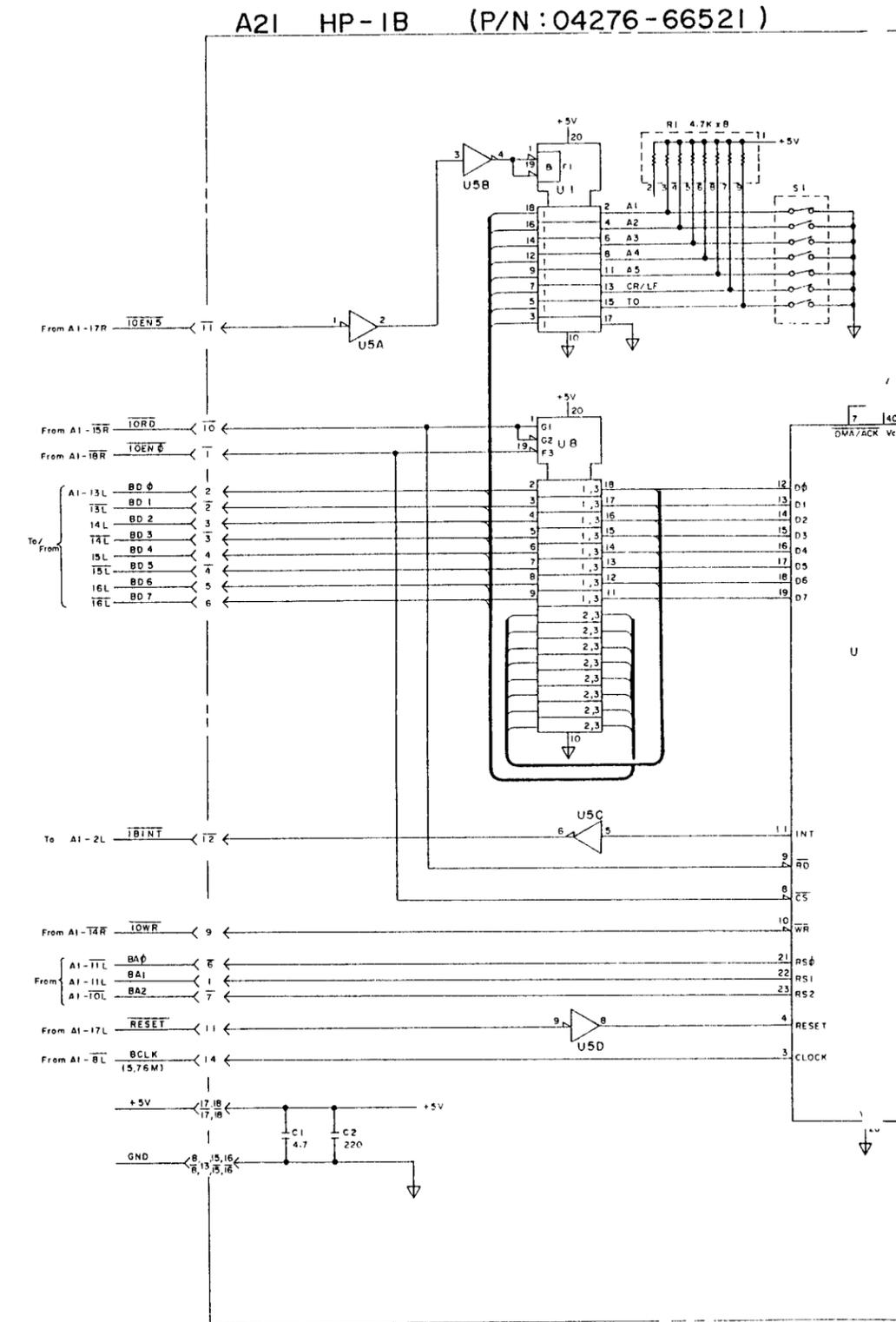
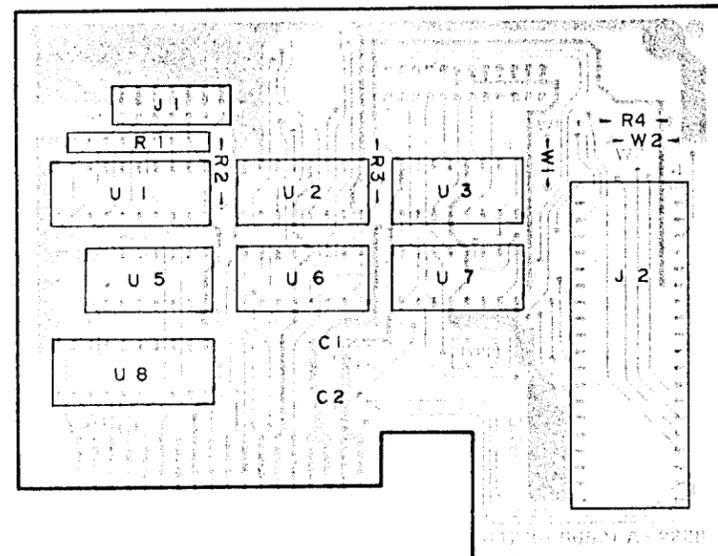
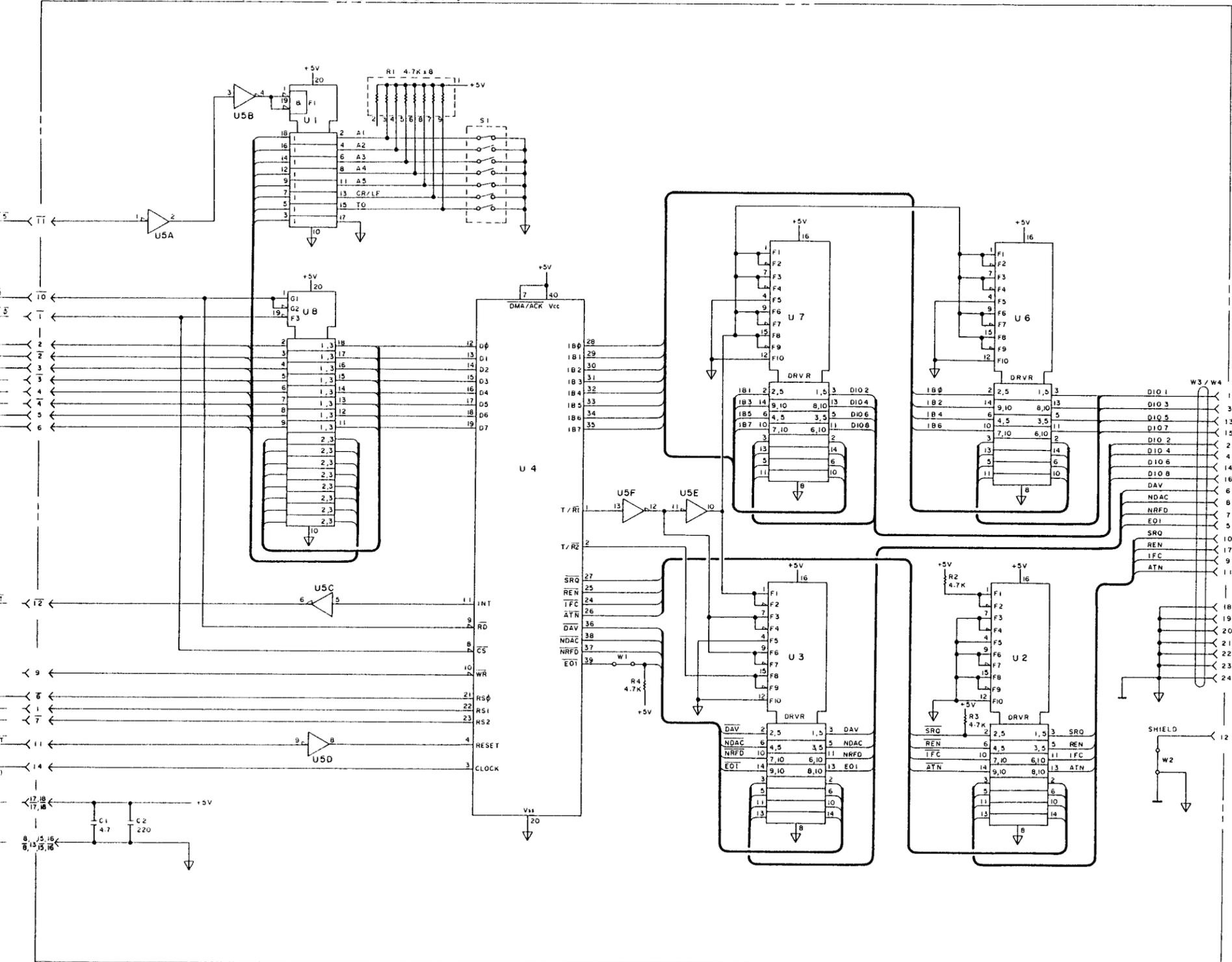


Figure 8-XX. A21 HP-IB Board Assembly Component Locations.

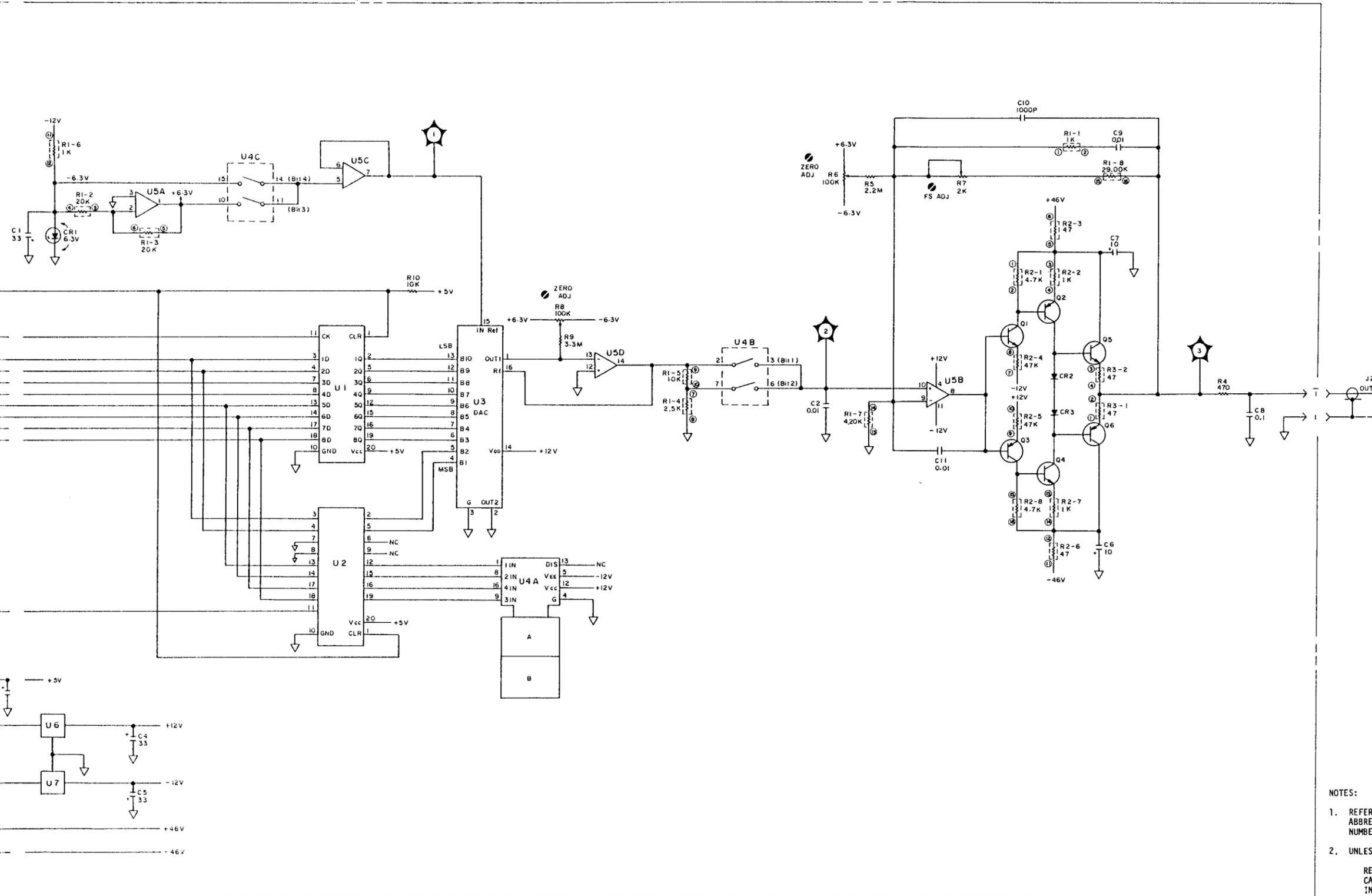
A21 HP-1B (P/N:04276-66521)



NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
2. UNLESS OTHERWISE INDICATED:
 RESISTANCE IN OHMS (Ω)
 CAPACITANCE IN MICROFARADS (μ F)
 INDUCTANCE IN MICROHENRIES (μ H)

OPTION 001 INTERNAL DC BIAS (P/N:04276-66522)



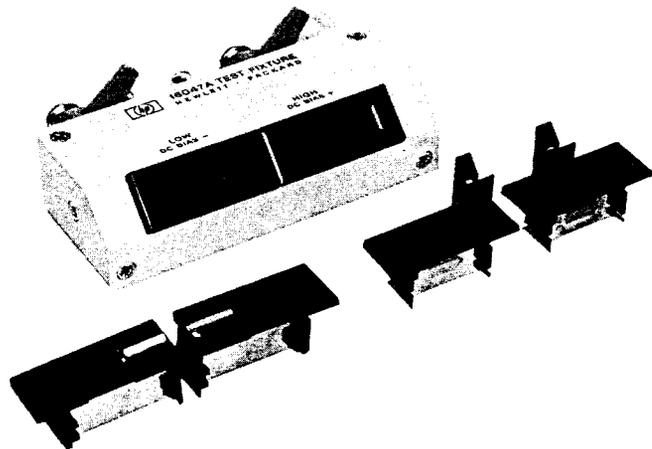
NOTES:

1. REFERENCE DESIGNATORS WITHIN THIS ASSEMBLY ARE ABBREVIATED. PREFIX ABBREVIATION WITH ASSEMBLY NUMBER FOR COMPLETE REFERENCE DESIGNATOR.
2. UNLESS OTHERWISE INDICATED:
RESISTANCE IN OHMS (Ω)
CAPACITANCE IN MICROFARADS (μ F)
INDUCTANCE IN MICROHENRIES (μ H)

OPERATING NOTE

TEST FIXTURE

16047A



APR. 1984

 **HEWLETT
PACKARD**

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

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

1. INTRODUCTION

This operating note provides complete information on the Hewlett-Packard Model 16047A Test Fixture. The 16047A is shown pictorially on the front-cover, its physical dimensions are given in Table 1, and typical characteristics related to offset error are given in Table 2. To order additional copies of this operating note, use the part number listed on the rear cover.

Table 1. Specifications.

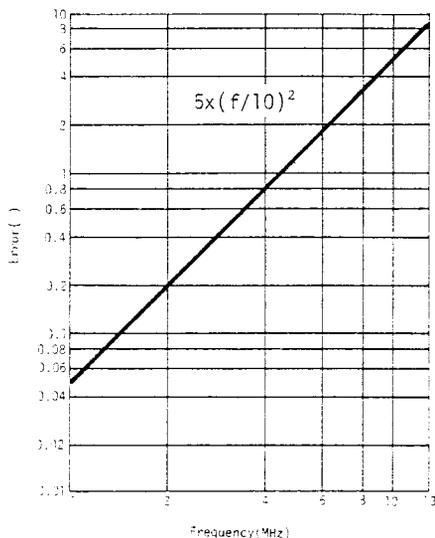
| |
|--|
| <p>Function: For use with Hewlett-Packard Models 4274A, 4275A, 4276A, 4277A, and 4192A. Permits connecting axial and radial lead components to the UNKNOWN terminals (4-terminal pair configuration) of the 4274A, 4275A, 4276A, 4277A, or 4192A.</p> <p>Contact Inserts: Three kinds: one for axial lead components, one for radial lead components, and one for radial short lead components.</p> <p>Dimensions in mm (inches): 124(4.9) x 31(1.2) x 62(2.4)</p> <p>Weight in grams (lbs): 205(0.45)</p> |
|--|

Table 2. Typical Characteristics.

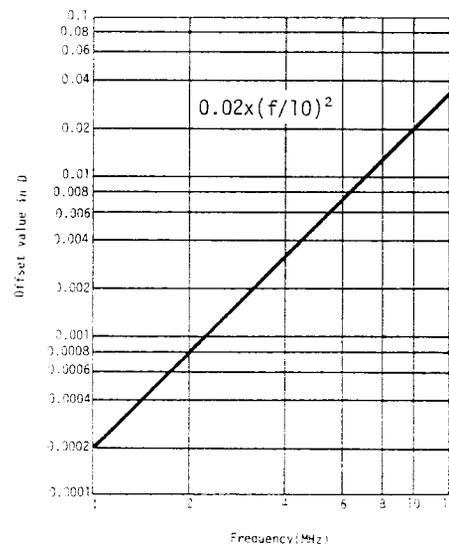
| Model | Applicable Measurement Ranges | | Incremental error at freq. \geq 1MHz | |
|--------|-------------------------------|-----------------------|---|---|
| | Parameter value | Measurement frequency | Parameter reading error | Offset value for D |
| 4274A* | Full range | Full range | / | |
| 4275A | | | $\pm 5 \times \left(\frac{f}{10}\right)^2 \%$ | $\pm 0.02 \times \left(\frac{f}{10}\right)^2$ |
| 4192A | | | | |

Note: f is the measurement frequency in megahertz. The incremental errors calculated from the equation in the table for measurements at frequencies above 1MHz are additive.

*: The maximum frequency of the 4274A is 100kHz.



Parameter reading error vs frequency.



Offset value in D vs frequency.

Table 2. Typical Characteristics (cont'd).

| Model | Applicable Measurement Ranges | | Incremental error at 1MHz | |
|---------|-------------------------------|-----------------------|---------------------------|--------------------|
| | Parameter value | Measurement frequency | Parameter reading error | Offset value for D |
| 4276A** | Full range | Full range | / | |
| 4277A | | | ±0.05% | ±0.0002 |

** : The maximum frequency of the 4276A is 20kHz.

2. DESCRIPTION

The Model 16047A Test Fixture is designed for use with the following instruments:

- Model 4192A LF Impedance Analyzer
- Model 4274A Multi-Frequency LCR Meter
- Model 4275A Multi-Frequency LCR Meter
- Model 4276A LCZ Meter
- Model 4277A LCZ Meter

It is a direct attachment, 4-terminal pair configuration type test fixture for measurements on both axial and radial lead components. Three contact inserts — labelled ①, ②, and ③ in Figure 1 — are available: one, ①, for measurements on axial components and two, ② and ③, for measurements on radial lead components. DC bias levels up to ±35V can be applied to the device under test (DUT) through this test fixture. When used with the 4276A or 4277A, however, the 16047A can handle dc bias voltages up to ±40V. The dimensions of the contact inserts are given in Figure 2.

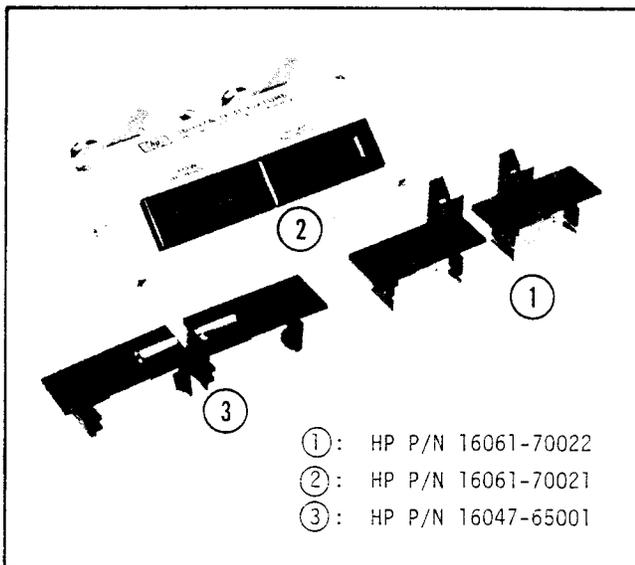


Figure 1. 16047A Test Fixture.

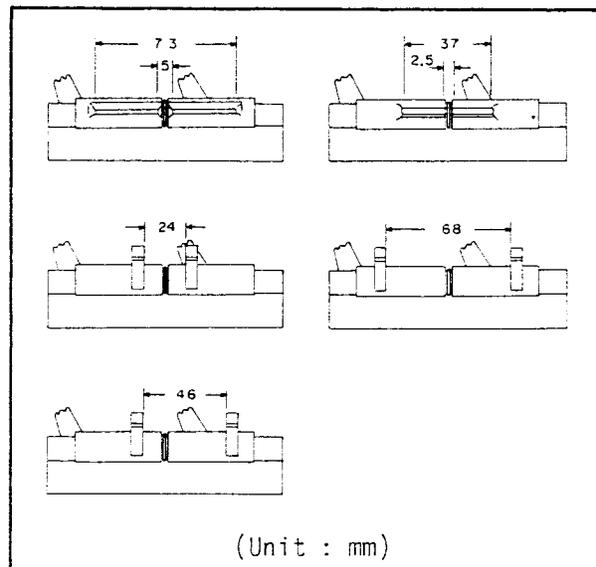


Figure 2. Dimensions of Test Fixture Contacts.

3. ZERO OFFSET ADJUSTMENT

The 16047A has inherent stray capacitance, residual inductance, and residual resistance that affect the accuracy of measured values. To compensate for, or negate, these residuals to minimize measurement error, the instrument's zero offset adjustment procedure should be performed. The procedure is given in Section III of the instrument's operating manual. For SHORT zero offset adjustments a low impedance copper or phosphor bronze shorting bar such as the one shown in Figure 3 is recommended.

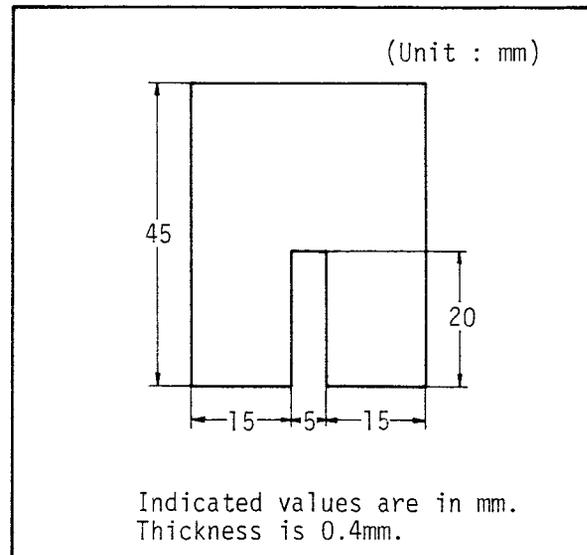


Figure 3. Shorting-bar dimensions.

4. OPERATION

Setup and measurement procedure is as follows:

- a. Set the CABLE LENGTH switch (4275A, 4277A and 4192A only) on the instrument's front-panel to 0m.
- b. Connect the 16047A directly to the UNKNOWN terminals of the instrument.
- c. Perform ZERO OFFSET ADJUSTMENT as described in Section III of the instrument's operating manual.
- d. Insert the DUT into the test fixture.

5. MAINTENANCE

The internal wiring of the 16047A is shown in Figure 4 and an exploded view — for parts identification — in Figure 5. Do not disassemble any further than shown. Maintenance consists principally of cleaning contacts and replacing worn or damaged parts. Take special care when cleaning contacts. To order parts, use the Hewlett-Packard part numbers listed in Figure 5. If a faulty part is located in an assembly that cannot be disassembled, order the next higher assembly or return the whole device to the nearest Hewlett-Packard Sales/Service Office for repair or replacement.

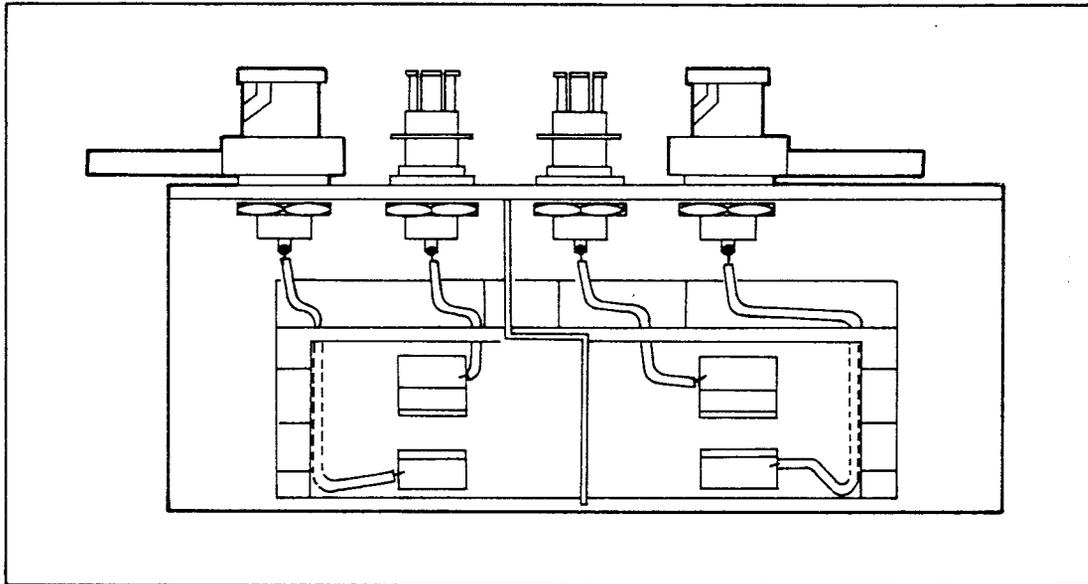


Figure 4. Internal Wiring of 16047A.

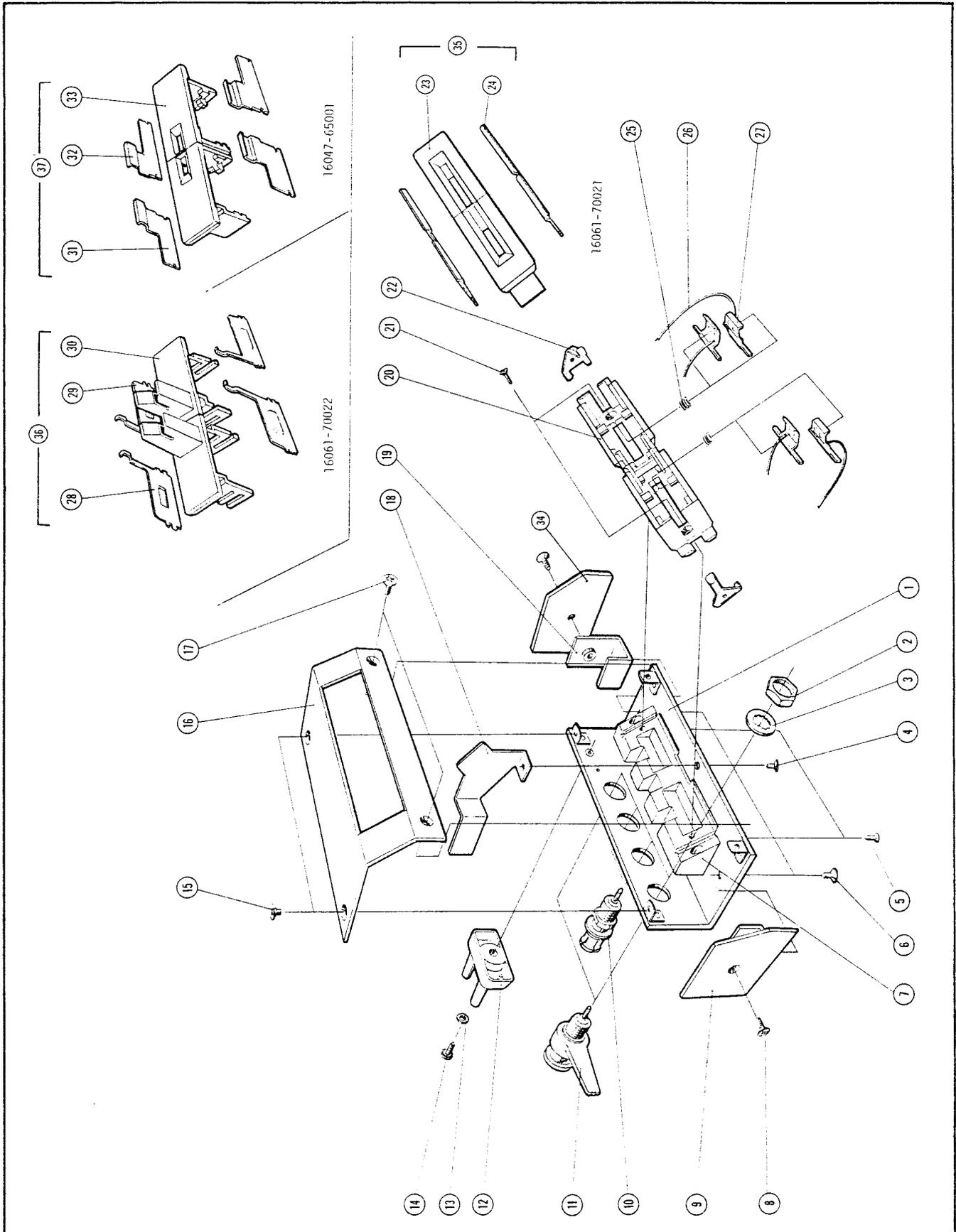


Figure 5. Parts Identification for 16047A (Sheet 1 of 2).

| Reference | HP Part No. | Qty | Description |
|-----------|-------------|-----|------------------------------------|
| 1 | 16047-04001 | 1 | COVER-BOTTOM |
| 2 | 2950-0043 | 4 | NUT |
| 3 | 2190-0016 | 4 | WASHER |
| 4 | 2200-0140 | 1 | SCREW |
| 5 | 0624-0203 | 2 | SCREW |
| 6 | 2360-0192 | 2 | SCREW |
| 7 | 16061-50022 | 1 | BASE |
| 8 | 2360-0192 | 2 | SCREW |
| 9 | 16047-00603 | 1 | SIDE PLATE (LEFT) |
| 10 | 1250-1798 | 2 | CONNECTOR-BNC |
| 11 | 16012-7122 | 2 | CONNECTOR-BNC |
| 12 | 16047-40000 | 1 | STOPPER |
| 13 | 3050-0229 | 1 | WASHER |
| 14 | 2200-0105 | 1 | SCREW |
| 15 | 2360-0192 | 2 | SCREW |
| 16 | 16047-04000 | 1 | COVER-TOP |
| 17 | 2360-0192 | 2 | SCREW |
| 18 | 16047-00600 | 1 | SHIELD PLATE |
| 19 | 16047-01200 | 2 | ANGLE |
| 20 | 16061-50023 | 1 | SOCKET |
| 21 | 0624-0202 | 2 | SCREW |
| 22 | 16061-10027 | 2 | SPRING |
| 23 | 16061-50031 | 1 | SOCKET-RADIAL |
| 24 | 16061-10031 | 4 | CONTACT-RADIAL |
| 25 | 1460-0343 | 2 | SPRING |
| 26 | 8150-0447 | 4 | WIRE |
| 27 | 16061-10026 | 4 | CONTACT |
| 28 | 16061-10033 | 2 | CONTACT-AXIAL |
| 29 | 16061-10032 | 2 | CONTACT-AXIAL |
| 30 | 16061-50032 | 1 | SOCKET-AXIAL |
| 31 | 16047-00604 | 2 | CONTACT |
| 32 | 16047-00605 | 2 | CONTACT |
| 33 | 16047-40001 | 2 | SOCKET |
| 34 | 16047-00602 | 1 | SIDE PLATE (RIGHT) |
| 35 | 16061-70021 | 2 | SOCKET ASSEMBLY (23 and 24) |
| 36 | 16061-70022 | 2 | SOCKET ASSEMBLY (28 , 29 and 30) |
| 37 | 16047-65001 | 2 | SOCKET ASSEMBLY (31 , 32 and 33) |

Figure 5. Parts Identification for 16047A (Sheet 2 of 2).

M A N U A L C H A N G E S

4276A

LCZ METER

MANUAL IDENTIFICATION

Model Number: 4276A

Date Printed: JUL. 1983

Part Number: 04276-90000

This supplement contains important information for correcting manual errors and for adapting the manual to instruments containing improvements made after the printing of the manual.

To use this supplement:

Make all ERRATA corrections.

Make all appropriate serial number related changes indicated in the tables below.

| SERIAL PREFIX OR NUMBER | MAKE MANUAL CHANGES | SERIAL PREFIX OR NUMBER | MAKE MANUAL CHANGES |
|-------------------------|---------------------|-------------------------|---------------------|
| 2517J01681 and above | 1 | | |
| | | | |
| | | | |
| | | | |

► NEW ITEM

► CHANGE 1

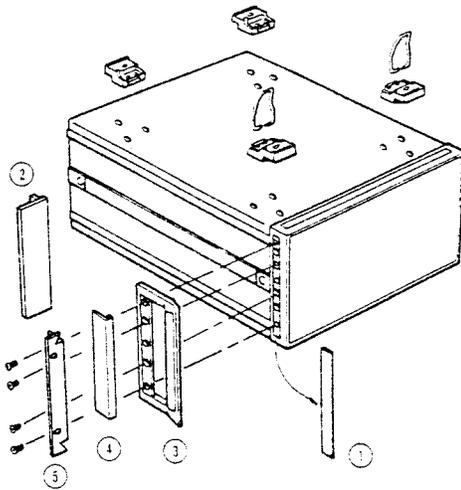
Page 2-5, Figure 2-3;

Change the Figure as shown on the next page.

NOTE

Manual change supplements are revised as often as necessary to keep manuals as current and accurate as possible. Hewlett-Packard recommends that you periodically request the latest edition of this supplement. Free copies are available from all HP offices. When requesting copies quote the manual identification information from your supplement, or the model number and print date from the title page of the manual.

| Option | Description | Kit Part Number |
|--------|--------------------------|-----------------|
| 907 | Handle Kit | 5061-9690 |
| 908 | Rack Flange Kit | 5061-9678 |
| 909 | Rack Flange & Handle Kit | 5061-9684 |



1. Remove adhesive-backed trim strips (1) from side at right and left front of instrument.
2. HANDLE INSTALLATION : Attach front handle (3) to sides at right and left front of instrument with screws provided and attach trim (4) to handle.
3. RACK MOUNTING : Attach rack mount flange (2) to sides at right and left front of instrument with screws provided.
4. HANDLE AND RACK MOUNTING : Attach front handle (3) and rack mount flange (5) together to sides at right and left front of instrument with screws provided.
5. When rack mounting (3 and 4 above), remove all four feet (lift bar at inner side of foot, and slide foot toward the bar).

Figure 2-3. Rack Mount Kit.