Errata

Title & Document Type: **8655A Synchronizer / Counter Operating and Service Manual**

Manual Part Number: **08655-90001**

Revision Date: **March 1976**

About this Manual

We've added this manual to the Agilent website in an effort to help you support your product. This manual provides the best information we could find. It may be incomplete or contain dated information, and the scan quality may not be ideal. If we find a better copy in the future, we will add it to the Agilent website.

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, life sciences, and chemical analysis businesses are now part of Agilent Technologies. The HP XXXX referred to in this document is now the Agilent XXXX. For example, model number HP8648A is now model number Agilent 8648A. We have made no changes to this manual copy.

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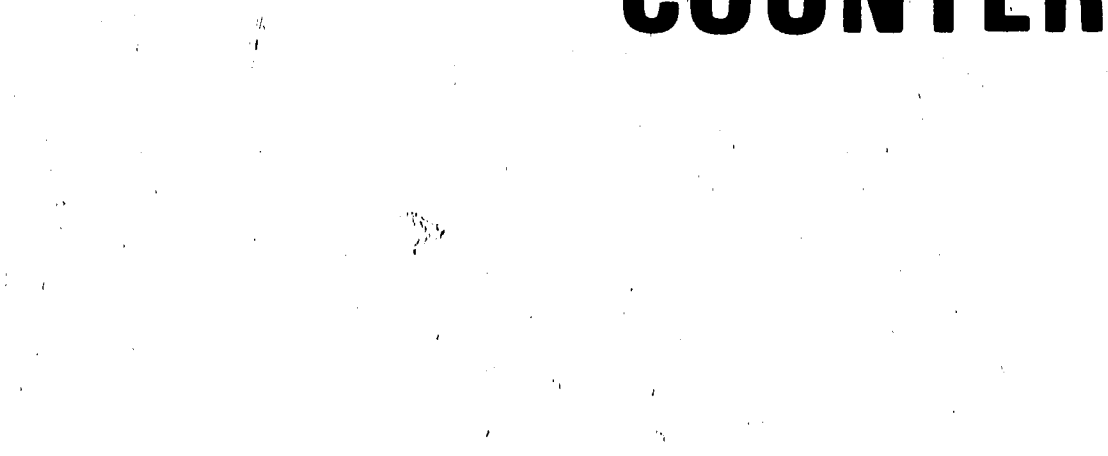
Agilent Technologies

HP 8655A

OPERATING AND SERVICE MANUAL

8655A
SYNCHRONIZER/ COUNTER



HEWLETT hp PACKARD

HP 8655A

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facilities, or to the calibration facilities of other International Standards Organization members.

WARRANTY AND ASSISTANCE

This Hewlett-Packard product is warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery. Hewlett-Packard 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.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

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

HEWLETT PACKARD

OPERATING AND SERVICE MANUAL

8655A
SYNCHRONIZER/COUNTER
(including Option 001)

SERIAL NUMBERS

This manual applies directly to instruments with serial numbers prefixed 1541A.

For additional important information about serial numbers, see INSTRUMENTS COVERED BY MANUAL, in Section I.

1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U. S. A.

MANUAL PART NO. 08655-90001
Operating Information Supplement: 08655-90002
Microfiche Part No. : 08655-90003

Printed: MARCH 1976

CONTENTS

ILLUSTRATIONS

TABLES

SAFETY CONSIDERATIONS

GENERAL — This is a Safety Class I instrument (provided with terminal for protective earthing) and has been manufactured and tested according to international safety standards.

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

SERVICE — Although this instrument has been manufactured in accordance with international safety standards, this manual contains information, cautions, and warnings which must be followed to ensure safe operation. Service and adjustments should be performed only by qualified service personnel, and the following warnings should be observed.

WARNINGS

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

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

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

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

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

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuseholders must be avoided.

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

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

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

SAFETY SYMBOLS

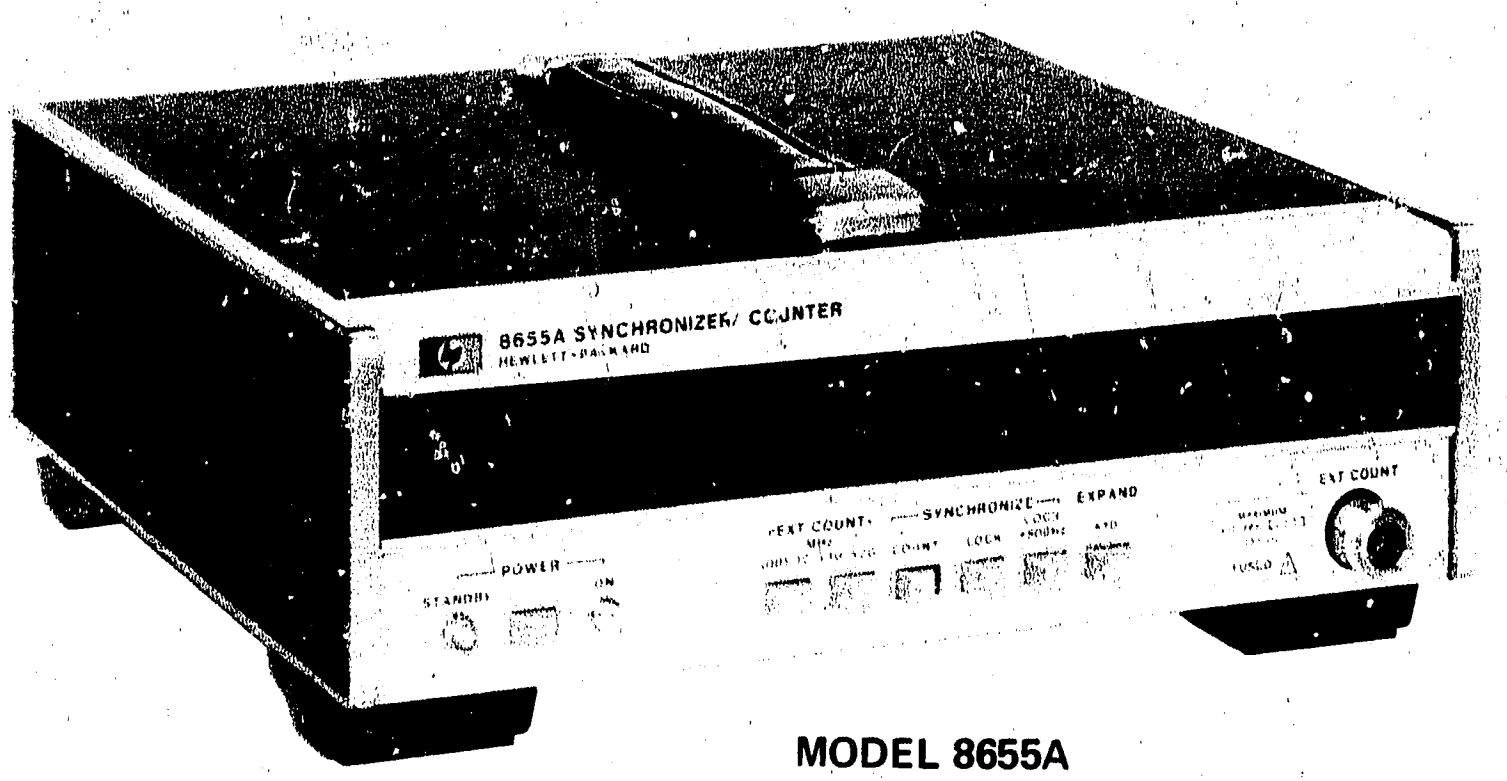
Instruction Manual symbol: The apparatus will be marked with this symbol when it is necessary for the user to refer to the instruction manual in order to protect the apparatus against damage.

Indicates dangerous voltages.

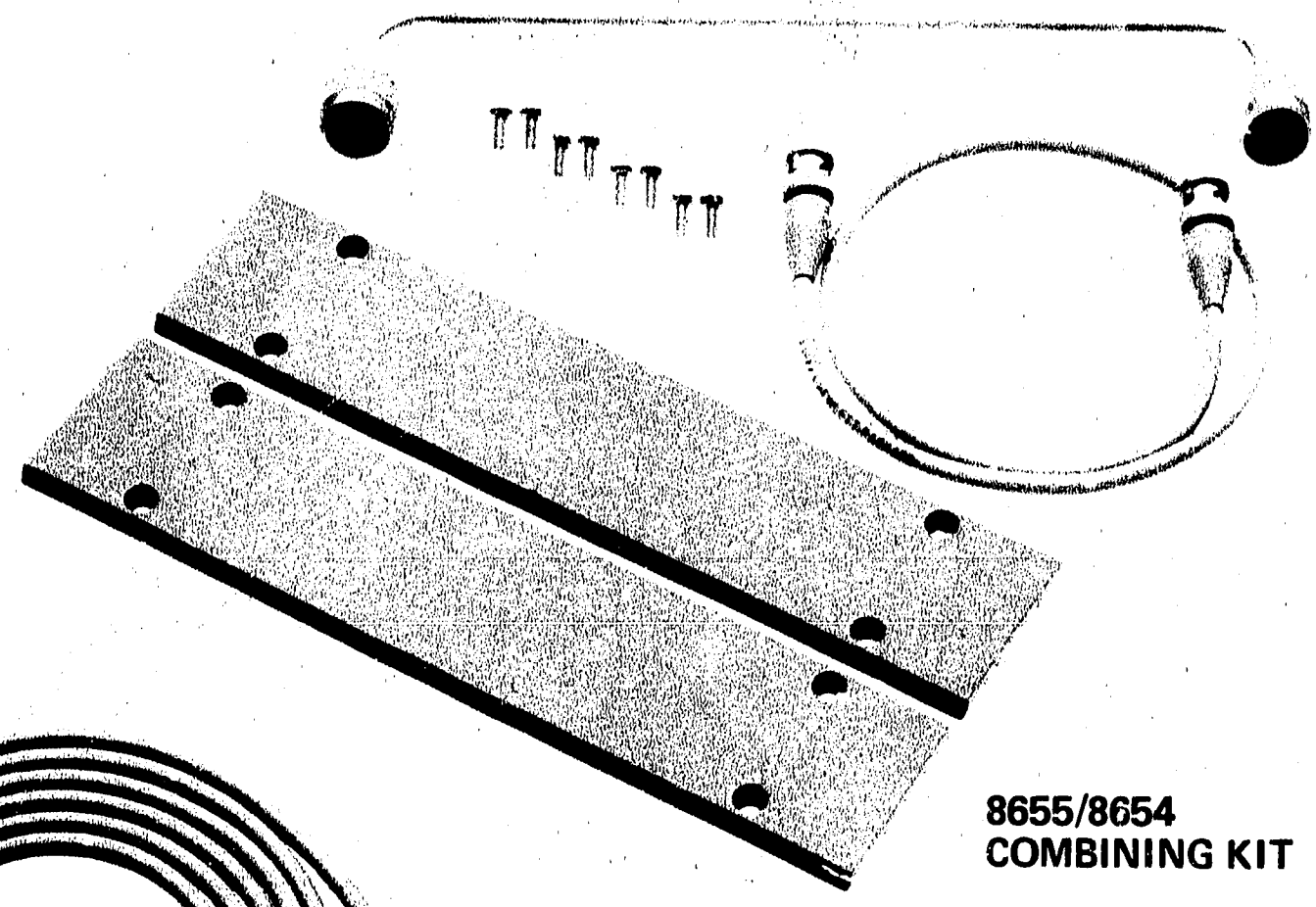
Earth terminal.

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

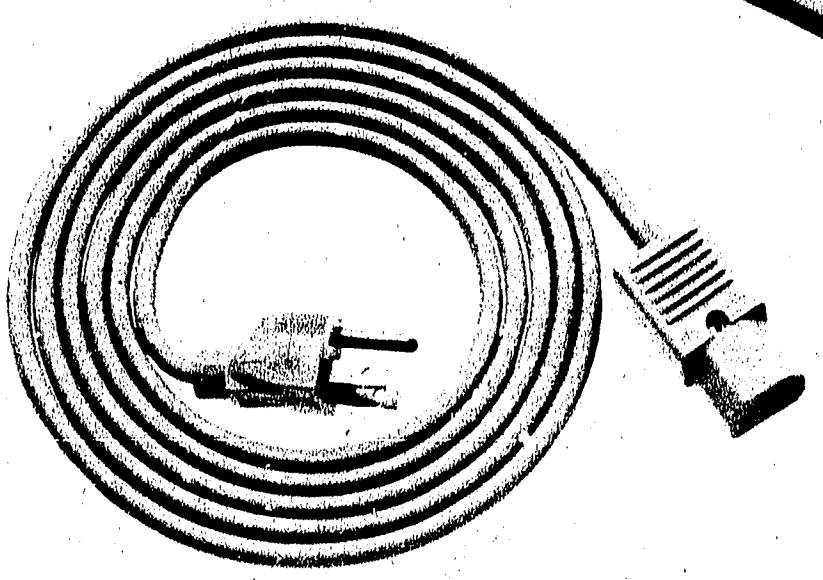
CAUTION The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the equipment. Do not proceed beyond a CAUTION sign until the indicated conditions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



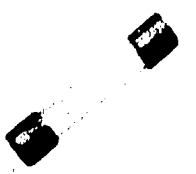
MODEL 8655A



8655/8654
COMBINING KIT



LINE POWER CABLE



FUSE

Figure 1-1. HP Model 8655A Synchronizer/Counter and Accessories

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This manual contains operating and service information for the Hewlett-Packard Model 8655A Synchronizer/Counter including Option 001, High Stabiiity Time Base. The Synchronizer/Counter is shown in Figure 1-1 with all of its externally supplied accessories.

1-3. This section of the manual describes the instruments documented by this manual and covers instrument description, options, accessories, specifications and other basic information. The other sections provide the following:

Section II, Installation: information about initial inspection, preparation for use, and storage and shipment.

Section III, Operation: information about panel features, and provides operating checks, instructions, and maintenance information.

Section IV, Performance Tests: information required to check basic instrument functions and to verify that the instrument is performing as specified in Table 1-1.

Section V, Adjustments: information required to properly adjust and align the instrument.

Section VI, Replaceable Parts: ordering information for all replaceable parts and assemblies.

Section VII, Manual Changes: reserved to provide manual change information in future revisions of this manual.

Section VIII, Service: information required to repair the instrument.

1-4. Packaged with this manual is an Operating Information Supplement. This is a copy of the first three sections of this manual, and should stay with the instrument for use by the operator. Additional copies can be ordered through your nearest Hewlett-Packard Sales and Service Office; the part number is listed on the title page of this manual and on the rear cover of the supplement.

1-5. Also 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 96 photo duplicates of the manual's pages. The microfiche package also includes the latest Manual Changes supplement as well as all pertinent Service Notes.

1-6. SPECIFICATIONS

1-7. Instrument specifications are listed in Table 1-1. These specifications are the performance standards or limits against which the instrument can be tested.

1-8. INSTRUMENTS COVERED BY MANUAL

1-9. This instrument has a two-part serial number. The first four digits and the letter comprise the serial number prefix which identifies the instrument configuration. The last five digits form the suffix that is unique to each instrument. The contents of this manual apply directly to instruments having the same serial number prefix(es) as listed under SERIAL NUMBERS on the title page.

1-10. 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 prefix indicates that the instrument is different from those documented in this manual. The manual for this instrument is supplied with a yellow Manual Changes supplement that contains change information that documents the differences.

1-11. In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is keyed to this manual's print date and part number, both of which appear on the title page. Complimentary copies of the supplement are available from Hewlett-Packard.

1-12. For information concerning a serial number prefix not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

1-13. DESCRIPTION

1-14. The HP 8655A Synchronizer/Counter is a phase lock frequency stabilizer that provides HP 8654A and 8654B signal generators with crystal oscillator frequency stability. Thus the generator can attain the drift stability of the counter's time base reference or an external 1 MHz reference. The HP 8655A is also a 1 kHz to 520 MHz frequency counter with very low RFI leakage. When used with an 8654 signal generator, frequency can be phase locked over the range of 10 to 520 MHz with spectral purity preserved. Two 8654/8655A combinations can also be locked together for various intermodulation distortion measurements.

1-15. FM capability of the 8654B is retained in the locked mode. FM can be added to a locked 8654A by summing a modulation signal with the phase lock signal at the generator's FM input.

1-16. In phase lock mode, a lock resolution of 500 Hz is possible. In count mode, resolution of 1 Hz is attainable in the 1 kHz to 10 MHz range or 100 Hz in the 10 to 520 MHz range.

1-17. OPTION 001

1-18. Option 001 is the Synchronizer/Counter with a high stability oven controlled crystal oscillator time base reference.

1-19. ACCESSORIES SUPPLIED

1-20. The Synchronizer/Counter is supplied with the following accessories (shown in Figure 1-1 and fully described in Sections II and III).

8655/8654 Combining Kit
Line Power Cable
0.75A Power Line Fuse for 220/240V operation

1-21. The following accessories are mounted inside the instrument's chassis.

Spare 5A fuse for power supply regulators (see F1-3 in Section VI for HP part number.)

Spare 0.125A fuse for counter's RF input (see Section III for HP part number).

1-22. EQUIPMENT AVAILABLE

1-23. The following instruments or accessories are available from Hewlett-Packard to enhance the usefulness or convenience of the instrument.

HP 105A Quartz Frequency Standard (not compatible with 8655A Option 001)

Rack Mounting Adapter (HP 5060-8764)

1-24. WARRANTY

1-25. The Synchronizer/Counter is warranted and certified as indicated on the inner front cover of this manual. For further information, contact the nearest Hewlett-Packard Sales and Service office; addresses are provided at the back of this manual.

1-26. TEST EQUIPMENT REQUIRED

1-27. Table 1-2 lists the test equipment and accessories required to check, adjust and repair the Synchronizer/Counter. If substitute equipment is used it must meet the listed critical specifications.

NOTE

This is a Safety Class I instrument (provided with terminal for protective earthing) and has been manufactured and tested according to international safety standards.

Table 1-1. Specifications

8655A SPECIFICATIONS

Counter Characteristics

Range: 1 kHz to 520 MHz.
Sensitivity: <100 mVrms (−7 dBm), ac coupled into 50 ohms. (Typically <−20 dBm, 10 kHz to 200 MHz).
Maximum input: ac: 707 mVrms (+10 dBm) for accurate count. dc: ±25 Vdc. Both inputs are protected with common fuse.

Count resolution: 6-digit LED display.

Mode	Normal	x10 EXPAND [1]
1 kHz to 10 MHz (EXTERNAL)	10 Hz	1 Hz
10 to 520 MHz (EXTERNAL & SYNCHRONIZE COUNT)	1 kHz	100 Hz

Accuracy: ±1 count ± time base accuracy.

Time Base Characteristics

Frequency: 1 MHz temperature-compensated crystal oscillator.
Aging (constant ambient temperature): <0.1 ppm/hr., <2 ppm/90 days.
Temperature: ±5 ppm from 0° to 50°C. (Referenced to 25°C.)
Typical Overall Accuracy (after 2 hours warm-up and within 3 months of calibration): Better than ±2 ppm from 15° to 35°C. (Option 001 higher stability time base available.)
Rear Output: 1 MHz, nominally >0.5 volts peak-to-peak 500 ohms.
External Reference Input: 1 MHz, nominally > 0.5 volts peak-to-peak into 1000 ohms. (Not available with Option 001 high stability time base.)

Option 001 High Stability Time Base Characteristics

Specifications apply after two-hour warm-up

Frequency: 1 MHz oven-controlled crystal oscillator.
Aging: < 0.003 ppm/day.
Temperature: ± 0.03 ppm from 0° to 55°C.

Option 001 High Stability Time Base Characteristics (cont'd)

Retrace: Following a 72-hour off period the oscillator frequency shall be within 0.03 ppm of the frequency at turn-off after 1 hour of operation. (Operating the instrument in the standby position eliminates the retrace error.)
Typical Overall Accuracy (within 3 months of calibration): ±0.3 ppm, from 0° to 55°C.

General

RF Leakage (when operated with 8654B using furnished interface cables): less than 1.5 μV in a 2-turn, 1-inch diameter loop, 1 inch away from any surface and measured into a 50-ohm receiver.
Power: 100, 120, 220, or 240 volts +5%, −10%, 48 to 400 Hz, 100VA maximum, 2.29 m (7½ ft) power cable.
Weight: net, 6 kg (13 lbs 3 oz).
Dimensions: 266 mm W x 101.6 mm H x 317.5 mm D (10½ in. x 4 in. x 12½ in.).

8654/8655A SPECIFICATIONS

Synchronization Characteristics

Frequency Range: 10 to 520 MHz.
Frequency Count Resolution: 1 kHz , or 100 Hz in x10 EXPAND.
Frequency Lock Resolution: 1 kHz; depressing LOCK +500 Hz button allows a locked resolution of 500 Hz.
Frequency Accuracy: same as time base accuracy.
Lock Time Duration (after 5 minute warm-up, constant ambient): 45 min. typical.
FM Rate While Synchronized: 50 Hz to >25 kHz.
FM Accuracy (with 8654B only):

$$\begin{bmatrix}\text{Total FM}\\ \text{Accuracy}\end{bmatrix} = \begin{bmatrix}\text{8654B FM}\\ \text{Accuracy}\end{bmatrix} \pm \begin{bmatrix}\text{Frequency}\\ \text{Correction Error}\end{bmatrix}$$

Frequency correction error[2] is typically <±4%.

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[1] Will continue to accurately count from 1 to 10 MHz and from 100 to 520 MHz with loss of most significant digit (indicated by overflow light). Phase lock is not allowed.

[2] Frequency correction error is a function of the unlocked 8654B frequency drift. For optimum FM accuracy, this error may be eliminated by unlocking, retuning to the desired frequency, and relocking.

Table 1-2. Recommended Test Equipment (1 of 2)

Instrument Type	Critical Specifications	Suggested Model	Use*
Frequency Counter	Range: to 520 MHz Input Sensitivity: <100 mV Inputs: 50Ω and 1 MΩ (high impedance) Accuracy: typically 10^{-7} Time Base: 10 MHz (Internal and External) Display: 7 digits Functions: Frequency and Period	HP 5327C	T
Frequency Standard	Frequency: 10 MHz, 5 MHz, 1 MHz or 100 kHz Accuracy: $<10^{-7}$ (preferred)	Suitable House Standard	A
Multimeter	Voltage Range: 100 V to ≤1V Display: 4½ digits DC Accuracy: ± (0.03% of reading + 0.02% of range) Resistance Range: to 1 MΩ	HP 34702A/34740A	A, T
One-inch Loop Antenna	2-turn, 1-inch dia., 1 inch from end To ensure measurement accuracy, no substitution is possible. Fabrication depends upon machining and assembling to very close tolerances.	HP 08640-60501	P
Oscilloscope	Bandwidth: 50 MHz Sensitivity: 5 mV/division Triggering: Internal and External	HP 1820C/1801A/ 182C	A,T
Signal Generator	Range: 10 – 520 MHz Output Level: +10 to –7 dBm Compatible Phase Lock or FM Input Leakage (with all RF outputs terminated properly): Leakage limits are below those specified in MIL-I-6181D. Furthermore, with an output level <0.01V, less than 0.5 μV is induced in a 2-turn, 1-inch diameter loop 1 inch away from any surface and measured into a 50Ω receiver.	HP 8654A or HP 8654B	T P, T
Spectrum Analyzer	Range: 10—1200 MHz Amplitude Calibration: Display Accuracy: ±0.25 dB/dB but not more than 1.5 dB over 70 dB dynamic range Flatness: ±1 dB Vertical Reference Scale: 10 dB/division log Input Impedance: 50Ω Average Noise Level: <–120 dBm with 10 kHz IF bandwidth Spurious Responses: >60 dB down for inputs of –40 dBm or less Bandwidth: 30 kHz Span Width: >200 MHz.	HP 8558B/182C	P

* P = Performance, A = Adjustment, T = Troubleshooting.

Table 1-2. Recommended Test Equipment (2 of 2)

Instrument Type	Critical Specifications	Suggested Model	Use*
Test Oscillator	Range: 10 Hz to 10 MHz Output Impedance: 50Ω Output Level: >1 Vrms	HP 651B	P, T
10:1 Voltage Divider Probe (2 recommended)	Division Ratio: 10:1 Input Impedance: 10 MΩ Compatible with 1 MΩ inputs to Frequency Counter and Oscilloscope	HP 10004D	T
2 dB Amplifier	Range: 10—520 MHz Gain: 20 to 25 dB Flatness over Range: ±2 dB Impedance: 50Ω Noise Figure: <5 dB	HP 8447A	P
50Ω Load (2 required)	———	HP 11593A	P

*P = Performance, A = Adjustment, T = Troubleshooting.

INSTALLATION

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section provides information about incoming inspection, selecting the input line voltage, operating environment, and information applicable to bench and rack mounting.

2-3. INITIAL INSPECTION

2-4. 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 are shown in Figure 1-1, and the procedures for checking electrical performance are given in Section IV. If the contents are incomplete, if there is mechanical damage or defects, or if the instrument does not pass the electrical performance test, notify the nearest Hewlett-Packard office. If the shipping container is damaged or the cushioning material shows signs of stress, notify the carrier as well as the Hewlett-Packard office. Keep the shipping materials for the carrier's inspection. The HP office will arrange for repair or replacement without waiting for claim settlements.

2-5. PREPARATION FOR USE

2-6. Power Requirements

2-7. The Synchronizer/Counter requires a power source of 100, 120, 220, or 240 Vac +5% −10%, 48 to 440 Hz single phase. Power consumption is less than 100 VA.

2-8. Line Voltage Selection

2-9. Figure 2-1 provides instructions for line voltage and fuse selection. The line voltage selection card and the proper fuse are factory installed for 120 Vac operation.

CAUTION

To prevent damage to the instrument make the line voltage selection before connecting the power cable.

NOTE

The correct fuse rating for the line voltage is shown on the fuse compartment. More information is given in Table 3-1, Power Line Fuse Information.

2-10. Power Cable

2-11. In accordance with international safety standards, this instrument is equipped with a three-wire power cable. When connected to an appropriate ac power receptacle, this cable grounds the instrument cabinet. The type of power cable plug shipped with each instrument depends on the country of destination. Refer to Figure 2-2 for the part numbers of the power cable plugs available.

WARNINGS

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

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

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

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

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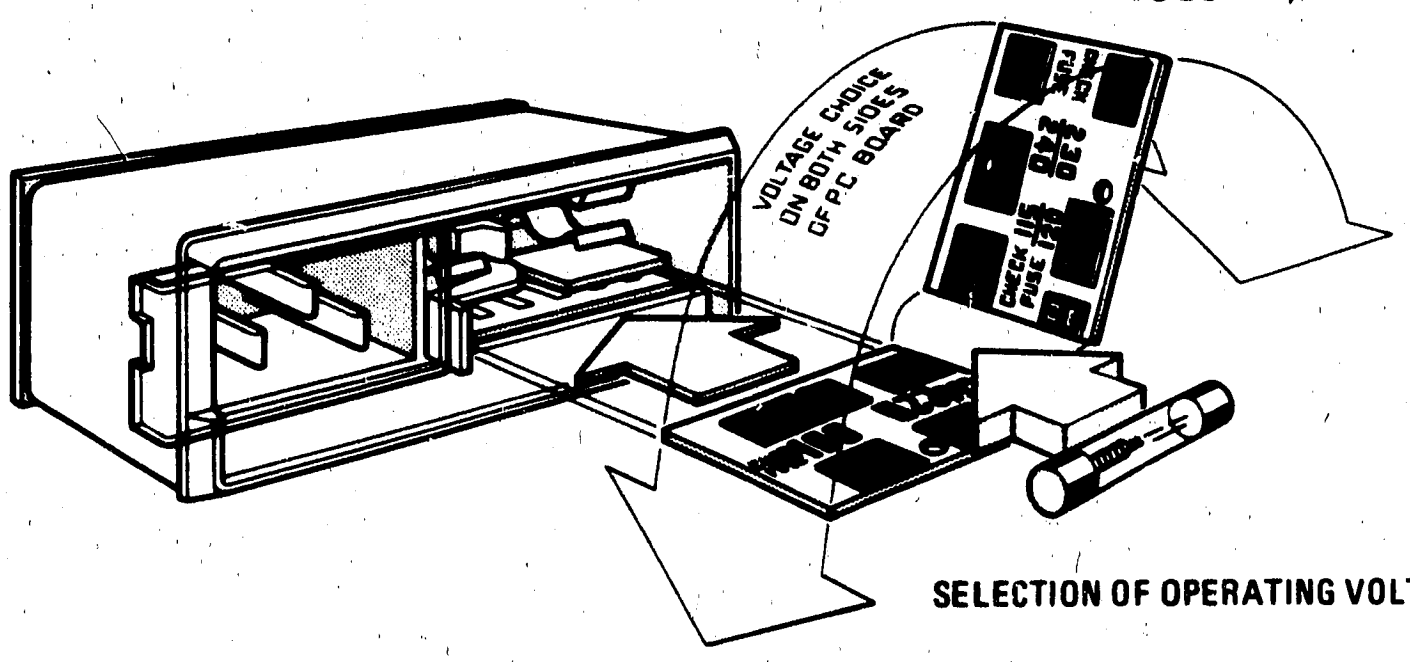


SELECTION OF OPERATING VOLTAGE

1. Open cover door and rotate fuse-pull to left.
2. Select operating voltage by orienting PC board to position desired voltage on top-left side. Push board firmly into module slot.
3. Rotate fuse-pull back into normal position and re-insert fuse in holders, using cautions to select correct fuse value.

Figure 2-1. Line Voltage Selection

Power Cable (cont'd)

WARNINGS (cont'd)

Make sure that only fuses with the required rated current and of the specified type (normal blow, time delay, etc.) are used for replacement. The use of repaired fuses and the short-circuiting of fuseholders must be avoided.

2-12. Mating Connectors

2-13. Mating connectors used with the Synchronizer/Counter should be either 50 ohm type BNC male or Type N male connectors that are compatible with US MIL-C-39012.

2-14. Operating Environment

2-15. The operating environment should be within the following limitations:

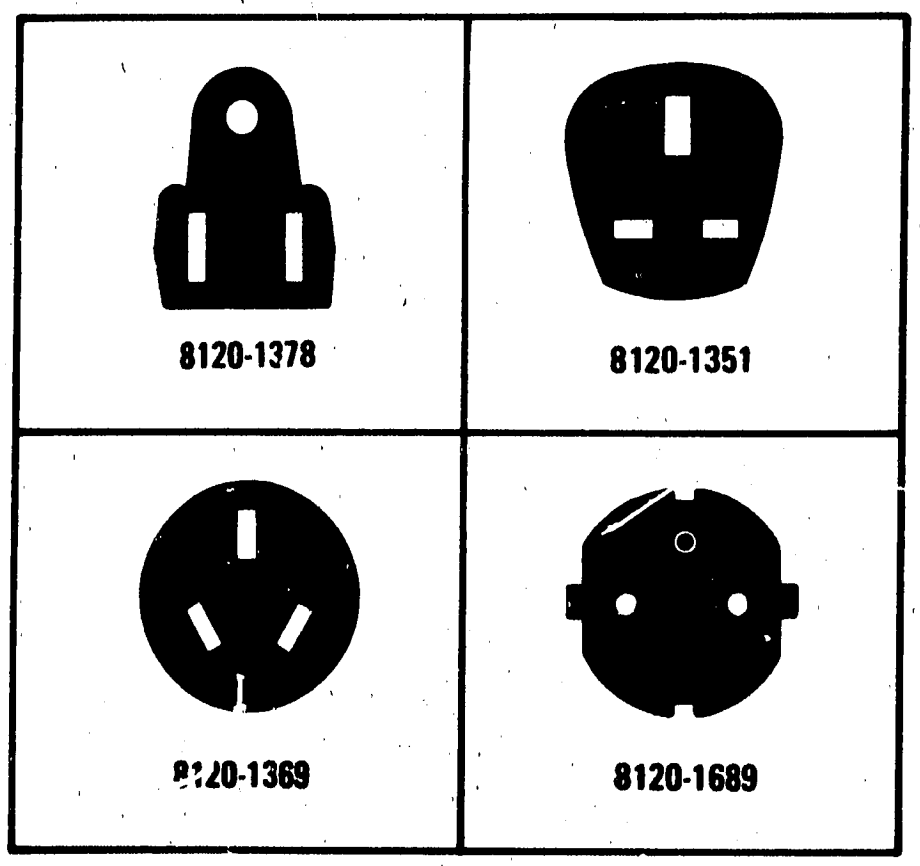


Figure 2-2. Power Cables Available

Operating Environment (cont'd)

Temperature . . . . . 0 to +55°C
Humidity . . . . . <95% relative
Altitude . . . . . <4600 metres (15,000 feet)

2-16. Bench Operation

2-17. The instrument cabinet has plastic feet and foldaway tilt stands for convenience in bench operation. The plastic feet are shaped to ensure self-aligning of the instruments when stacked. The tilt stands raise the front of the instrument for easier viewing of the control panel.

2-18. Combining Kit

2-19. An 8655/8654 Combining Kit is supplied with the Synchronizer/Counter (HP part number 08655-60021; see Figure 1-1). The kit contains combining rails, hardware and interconnect cables necessary to join the generator and Synchronizer/Counter as a single convenient unit for bench operation.

2-20. Refer to Figures 2-3 and 2-4, and the following steps to combine the two instruments.

a. Place Synchronizer/Counter on top of generator (do not remove plastic feet or generator's handle).

b. Remove appropriate screws from side panels of the instruments; position combining rails, and secure with the eight screws supplied in the kit.

c. For 8654B signal generators, make the cable interconnections shown in Figure 2-4. For 8654A generators, connect synchronizer's ϕ LOCK output to generator's FM input with FM modulation switch set to EXT. For older 8654A signal generators it may be necessary to use flexible BNC-to-BNC coaxial cable and BNC-to-Type N adapter to make RF connections.

d. **Minimize RF leakage from the Type N connectors in the following manner.** Place a receiver near the connectors. Set generator to appropriate frequency and modulation, and minimum output level. Carefully tighten connectors with pliers until minimum leakage is detected by receiver.

2-21. Rack Mounting

2-22. A rack mounting adapter is available, with necessary hardware and instructions, to prepare the instrument for mounting in a 19-inch instrument rack (see EQUIPMENT AVAILABLE in Section I for part number). When rack-mounted above an 8654 signal generator, the instruments can be electrically interconnected in the same manner as described for the Combining Kit.

2-23. STORAGE AND SHIPMENT

2-24. Environment

2-25. The instrument should be stored in a clean, dry environment. The following environmental limitations apply to both storage and shipment.

Temperature . . . . . −40 to +75°C
Humidity . . . . . <95% relative
Altitude . . . . . <7600 metres (25,000 feet)

2-26. Packaging

2-27. Original Packaging. Containers and materials identical to those used in factory packaging are available through Hewlett-Packard offices. 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-packaging with commercially available materials:

a. Wrap the instrument in heavy paper or plastic. (If shipping to a Hewlett-Packard office or service center, attach a tag indicating the type of service required, return address, model number, and full serial number.)

b. Use a 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 the instrument to provide a firm cushion and prevent movement inside the container. Protect the control panel with cardboard.

d. Seal the shipping container securely.

e. Mark the shipping container FRAGILE to assure careful handling.

Figure 2-3. Model 8655A and Model 8654B With Combining Rails

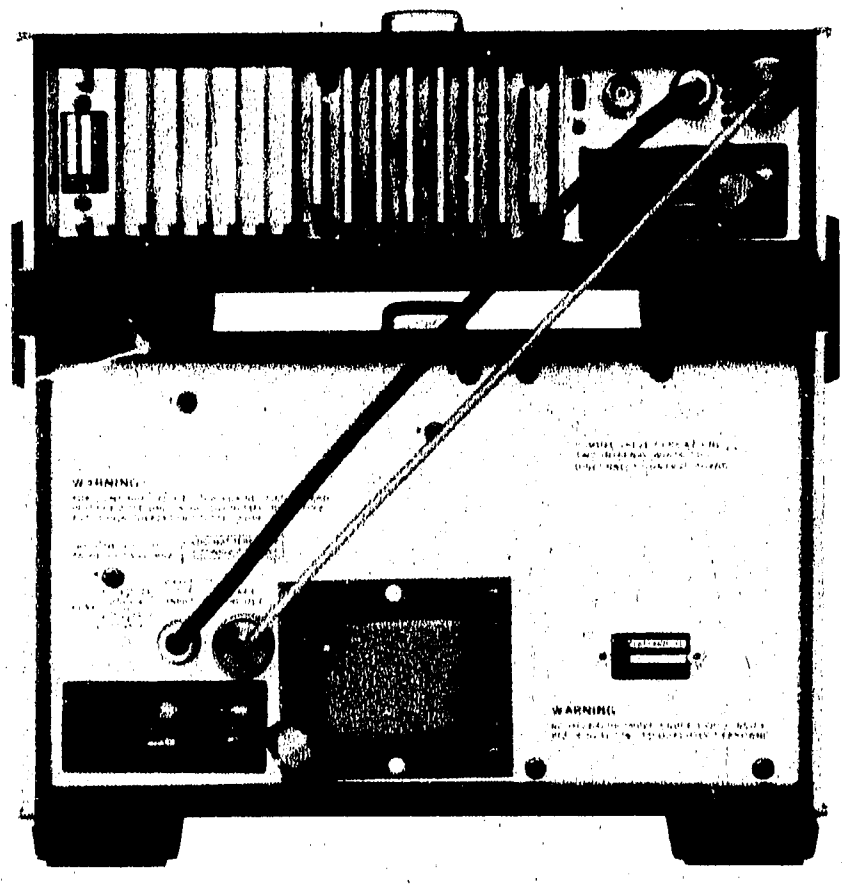


Figure 2-4. Model 8655A and Model 8654B Interconnections

OPERATION

SECTION III
OPERATION

3-1. INTRODUCTION

3-2. This section describes the functions of the controls and indicators of the Synchronizer/Counter. It describes how to set the counter and phase lock controls, and covers such operator maintenance as fuses and indicator lamp replacement.

3-3. PANEL FEATURES

3-4. Front panel controls, indicators, and connectors are shown and described in Figure 3-1. Rear panel controls and connectors are shown and described in Figure 3-2.

3-5. OPERATOR'S CHECKS

3-6. Use the operator's checks in Figure 3-3 to verify proper operation of the Synchronizer/Counter's main functions.

3-7. OPERATING INSTRUCTIONS

3-8. Figure 3-4 explains how to use the frequency counter and phase lock controls.

3-9. OPERATOR'S MAINTENANCE

CAUTION

Be sure to select the correct fuse rating for the selected line voltage (see LINE VOLTAGE SELECTION in Section II and Power Line Fuse information in Table 3-1).

3-10. Power Line Fuse. The main ac line fuse is located on the rear panel next to the line power cable jack. To remove the fuse, first remove the line power cable from its jack. Slide the fuse compartment cover to the left, then pull the handle marked FUSE PULL and remove the fuse. See Table 3-1 for replacement fuse information.

Table 3-1. Power Line Fuse Information

Operation	Description	HP Part Number
100—120V	1A, 250V, slow blow	2110-0007
220—240V	0.75A, 250V, slow blow	2110-0360

An internal switch is set at the factory for synchronizer compatibility with HP 8654B Signal Generators. Before synchronizer operation is possible with HP 8654A Signal Generators, the switch setting must be changed (by qualified service personnel only).

The switch is located inside the bottom cover on the A4 Power Supply/Control Board Assembly. It is identified on the board as S7 8654A/8654B (a nearby switch labeled S9 8654/OTHER is factory set to the 8654 position and generally left in that position).

WARNINGS

To avoid dangerous high voltage, disconnect line power cable before removing protective covers.

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

For Qualified Service Personnel Only. Disconnect the line power cable; remove bottom cover and locate switch labeled S7 8654A/8654B. Set the switch to appropriate position and replace bottom cover.

WARNINGS

To avoid dangerous high voltage, disconnect line power cable before removing protective covers.

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

3-11. RF Input Fuse. The RF input fuse is located inside the bottom cover on the A1 Counter/Lock Assembly. (Only qualified service personnel should attempt fuse replacement.) Disconnect the line power cable; remove the bottom cover and locate the 1/2-inch hex cap on the counter casting. Unscrew the hex cap and replace fuse; 0.125A, 125V, Fast Blow, HP 2110-0513. (A factory supplied spare fuse may be found on the A4 Power Supply/ Control Board Assembly near the POWER switch.) Replace the hex cap and bottom cover.

3-12. Lamp Replacement. To gain access to the front panel POWER STANDBY/ON lamps, unscrew the appropriate plastic lens that holds the lamp in place. HP part numbers for the lamps and lenses are as follows:

DS1, 2 12V Incandescent (T-1) Lamp, HP 2140-0259

MP2 Blue (STANDBY) Lens, HP 1450-0493

MP3 White (ON) Lens, HP 1450-0157.

3-13. Fan. The fan motor has factory lubricated, sealed bearings and requires no periodic maintenance.

FRONT PANEL FEATURES

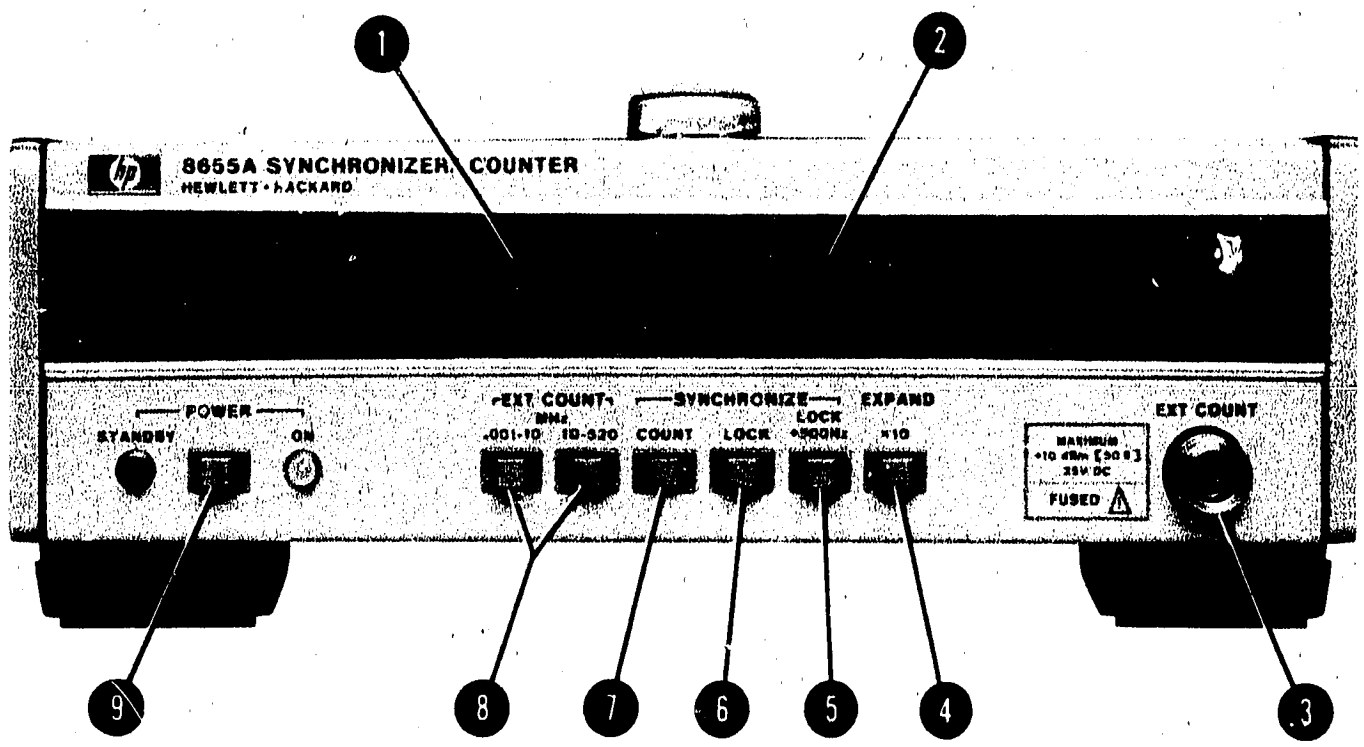


Figure 3-1. Front Panel Features (1 of 2)

FRONT PANEL FEATURES

1 **OVERFLOW Indicator:** lights to indicate that one or more significant digits have been shifted off the Frequency Display. Phase lock is not possible when OVERFLOW Lamp is on.

2 **Frequency Display:** counter readout indicates input frequency in megahertz. Blinking display indicates loss of phase lock.

3 **EXT COUNT Connector:** front panel, ac coupled, input to the Synchronizer/Counter. Input impedance is 50Ω. Input circuitry is fuse protected (see notes following SYNCHRONIZER LOCK Switch).

CAUTION

Do not apply >+10 dBm (707 mVrms into 50Ω) or >±25 Vdc to EXT COUNT input.

4 **EXPAND x10 Switch:** expands resolution one digit, moving decimal point one place to the left. Counter resolution of 1 Hz is possible in the 0.001—10 MHz mode, or 100 Hz in the 10—520 MHz mode (see notes following SYNCHRONIZE LOCK Switch).

5 **SYNCHRONIZE LOCK +500 Hz Switch:** locks the signal generator to the counter's crystal time base or to an external crystal reference. Frequency Display indicates the lock frequency whose least significant digit is 5 (500 Hz). When the Synchronizer/Counter is already in lock mode, depressing LOCK +500 Hz switch increases lock frequency by exactly 500 Hz. Loss of phase lock causes the Frequency Display to blink and the instrument to revert to count mode (see notes following SYNCHRONIZE LOCK Switch).

6 **SYNCHRONIZE LOCK Switch:** locks the signal generator to the counter's crystal time base reference or to an external crystal reference. Frequency Display indicates the locked frequency with a resolution of 1 kHz. Loss of phase lock causes the Frequency Display to blink and the instrument to revert to count mode.

NOTES

With EXPAND x10 switch depressed, it is not possible to depress the LOCK or LOCK +500 Hz switches.

Continued . . .

The Synchronizer/Counter can generally phase lock signals entering through the front panel EXT COUNT connector. However this is not recommended due to ambiguity that can arise in the 1 kHz to 10 MHz range. Phase lock is not specified, or possible over the entire range. Lock +500 Hz is also not possible even though indicated by the extra digit (3) illuminated on the Frequency Display.

7 **SYNCHRONIZE COUNT Switch:** switches counter input to rear panel RF IN connector. Counter frequency range is 10—520 MHz; resolution is 1 kHz normally or 100 Hz with EXPAND x10 Switch depressed (see note following .001—10 MHz Switch).

8 **EXT COUNT Switches:** switches counter input to front panel EXT COUNT connector.

10—520 MHz Switch: selects counter frequency range of 10—520 MHz; resolution is 1 kHz normally or 100 Hz with EXPAND x 10 Switch depressed (see note following .001—10 MHz Switch).

.001—10 MHz Switch: selects counter frequency range of 0.001—10 MHz; resolution is 10 Hz normally or 1 Hz with EXPAND x10 Switch depressed (see also note following SYNCHRONIZER LOCK Switch).

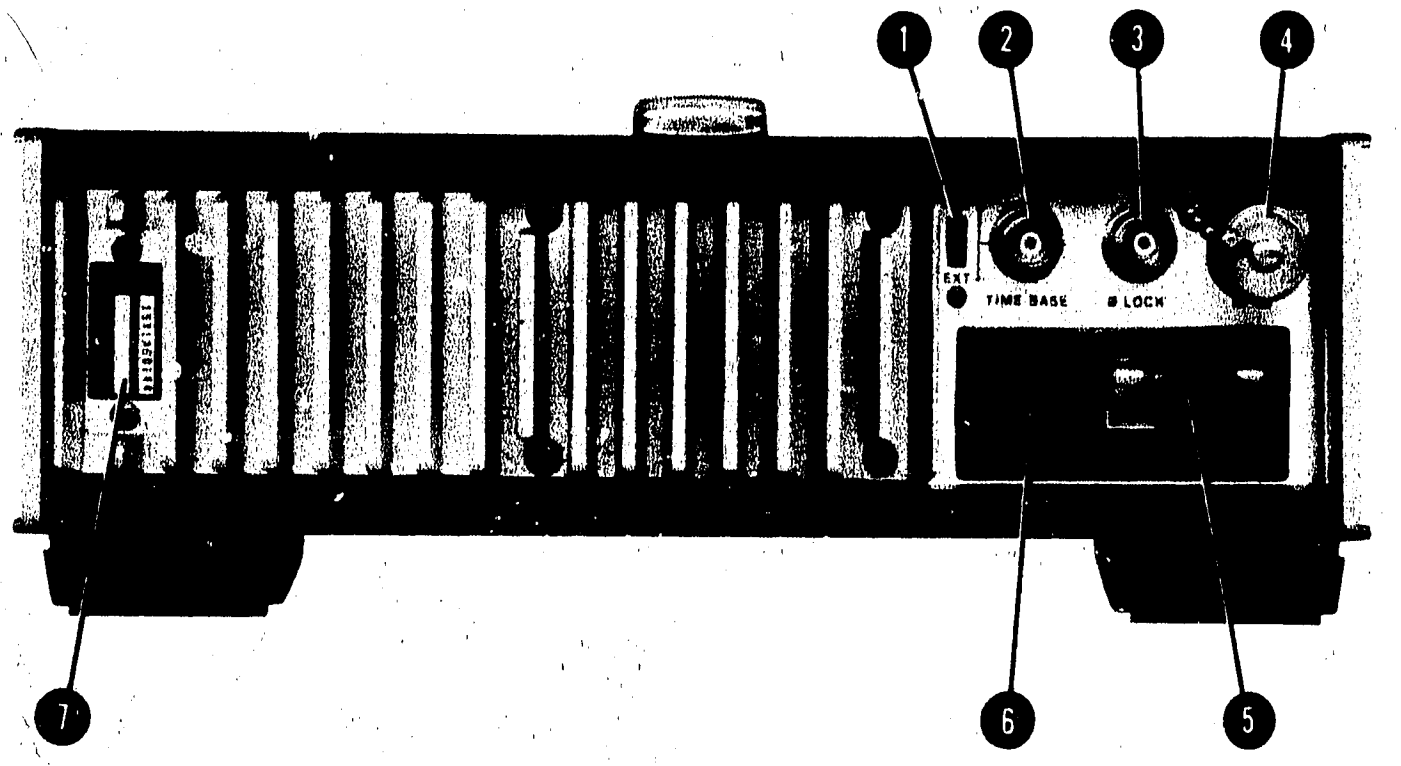
NOTE

SYNCHRONIZE COUNT switch and EXT COUNT 10—520 MHz and .001—10 MHz switches are interlocked so that only one button can be depressed at a time.

9 **POWER Switch:** selects STANDBY or ON. In the ON position, the entire instrument is energized. In STANDBY, power is supplied to the high stability time base crystal oscillator (Option 001 only). In a standard instrument, the STANDBY position should be considered "OFF".

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

REAR PANEL FEATURES



1 **TIME BASE Switch** (not available with Option 001): controls signal at TIME BASE connector. INT position switches the internal crystal reference signal to the connector. EXT position defeats the internal time base and directs an external reference signal through the connector to the counter's time base.

2 TIME BASE Connector: input for external 1 MHz time base reference, typically >0.5 Vp-p into 1000Ω (not available with Option 001). Output for internal 1 MHz time base reference, typically $>$ 0.5 Vp-p; source impedance, 509Ω (Standard and Option 001).

3 ¢ **LOCK Connector:** supplies the phase lock driving voltage to the signal generator (e.g., to the Phase Lock Input on an 8654B or FM Input on an 8654A).

4 **RF IN Connector:** rear panel, ac coupled, input to the Synchronizer/Counter. Frequency range is 10 to 520 MHz. Input impedance is 50Ω. Input circuitry is fuse-protected.

CAUTION

Do not apply $>$ +10 dBm (707 mVrms into 50Ω) or $>\pm$25 Vdc to RF IN.

5 **Fuse.** 1 Amp (250V, Slow Blow) for 100/120 Vac. 0.75 Amp (250V, Slow Blow) for 220/240 Vac.

6 **Line Power Module** Permits operation from 100,120, 220 or 240 Vac. The number visible in window indicates nominal line voltage to which instrument must be connected (see Figure 2-1). Center conductor is safety earth ground.

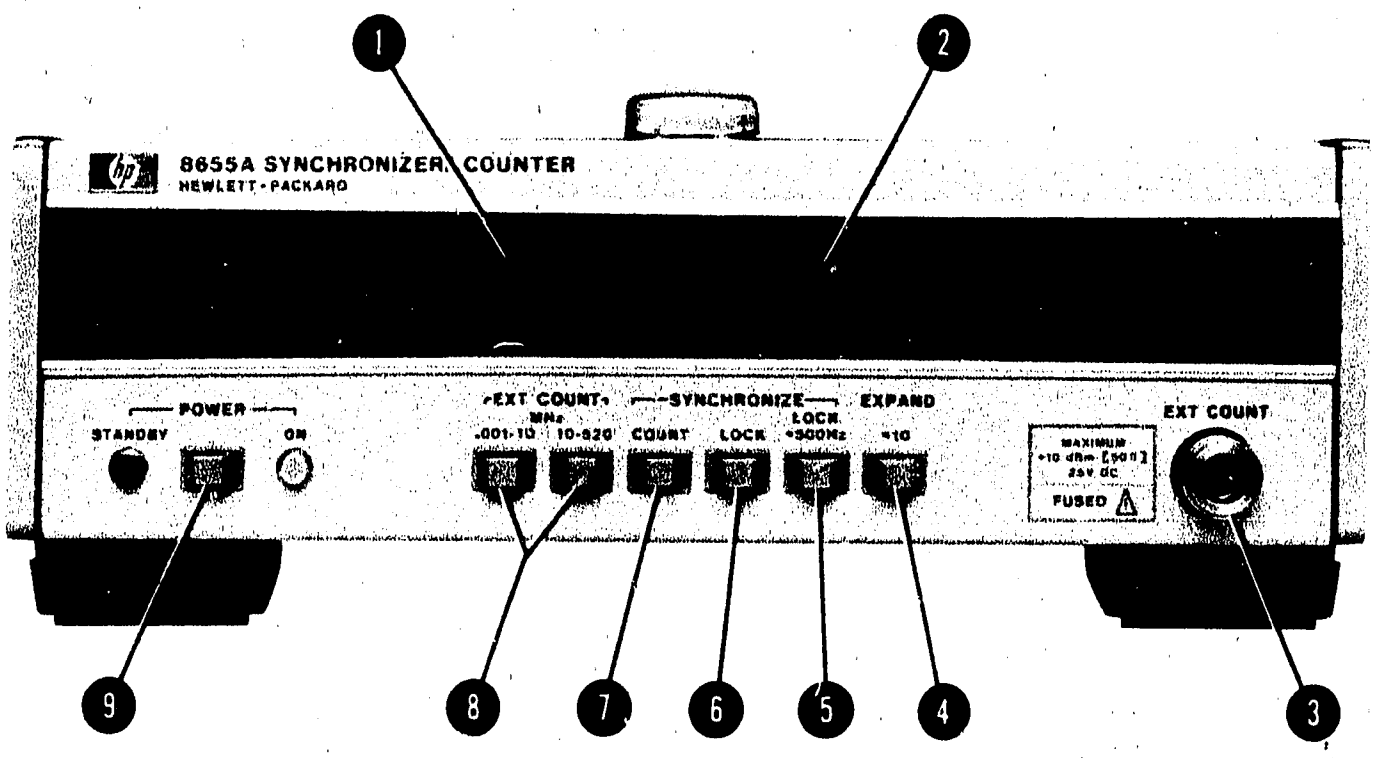
WARNING

Any interruption of the protective (grounding) conductor inside or outside the instrument or disconnection of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption is prohibited. (See Section II.)

7 **Serial Number Plate.** First four numbers and letter comprise the prefix that identifies the instrument configuration. The last five digits form the suffix that is unique to each instrument. The Serial Number plate also indicates any options supplied with the instrument.

Figure 3-2. Rear Panel Features

OPERATOR CHECKS



WARNINGS

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

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

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

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

Figure 3-3. Operator's Checks (1 of 3)

OPERATOR CHECKS

CAUTION

Do not apply >+10 dBm (707 mVrms into 50Ω) or > ±25 Vdc to front or rear panel RF inputs.

a. If necessary, the internal switches must be checked and set (by qualified service personnel) for compatibility with the signal generator being used (see procedure at beginning of this section).

b. Set POWER switch 9 to STANDBY (out). Connect line power cable to supply voltage. The blue STANDBY lamp should be illuminated.

c. Set rear panel TIME BASE switch to INT.

d. Set controls as follows:

9 POWER . . . . . ON
8 EXT COUNT: .001—10 MHz . . . . . In
6 LOCK . . . . . Out
5 LOCK + 500 Hz . . . . . Out
4 EXPAND x10 . . . . . Out

The white ON lamp should be illuminated and the Frequency Display 2 should indicate 0.00000.

Counter Checks

e. Use a Type N to BNC adapter and a BNC to BNC cable to connect the rear panel TIME BASE connector to the front panel EXT COUNT connector 3. The Frequency Display should indicate 1.00000 (1 MHz).

f. Depress EXPAND x10 button 4. Frequency Display 2 should indicate .000000 and the OVERFLOW lamp 1 should be illuminated.

g. Disconnect the cable between the TIME BASE and EXT COUNT connectors.

Phase Lock Checks

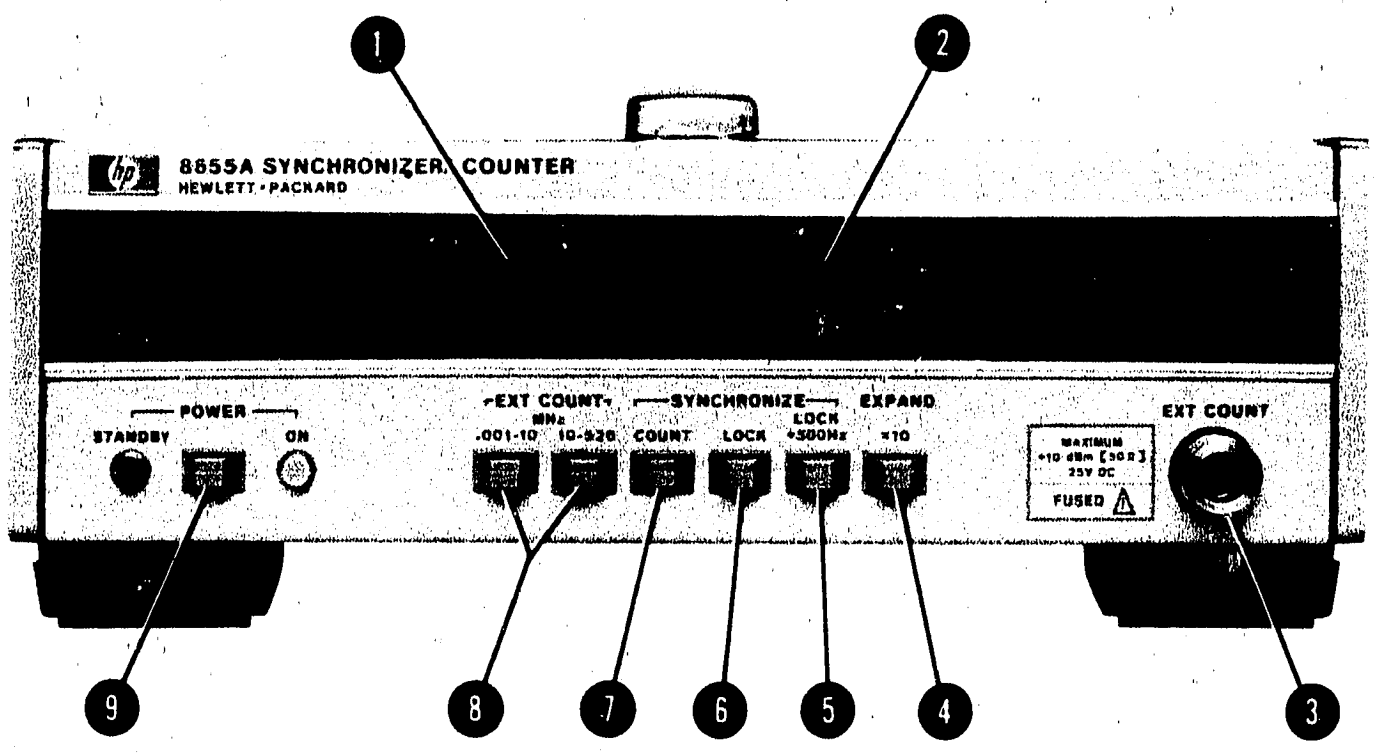
h. Connect the Synchronizer/Counter to the signal generator as follows.

RF IN (rear panel) to generator's auxiliary RF output.

ϕLOCK (rear panel) to generator's phase lock input (on 8654A Signal Generators, to FM INPUT with FM switch set to EXT).

Figure 3-3. Operator's Checks (2 of 3)

OPERATOR CHECKS



i. Set controls as follows.

9	POWER	ON
7	SYNCHRONIZE COUNT	In
6	LOCK	Out
5	LOCK + 500 Hz	Out
4	EXPAND x10	Out

The Frequency Display 2 should indicate the RF frequency of the signal generator. The last digit may be flickering between two numbers.

j. Depress the LOCK button 6. The flickering of the last digit should stop.

k. Adjust the generator's frequency away from the indicated lock frequency. Frequency Display 2 should begin blinking at about a 2 Hz rate, indicating loss of phase lock. Frequency Display should change and indicate the generator's RF frequency. To reset phase lock, release the LOCK button 6 and press it in again. Display blinking should stop and new lock frequency is shown.

l. Depress LOCK + 500 Hz. A new least significant digit (5) should appear indicating an increase in lock frequency of 500 Hz.

Figure 3-3. Operator's Checks (3 of 3)

OPERATING INSTRUCTIONS

WARNINGS

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

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

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

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

NOTE

If necessary, the internal switches must be checked and set (by qualified service personnel) for synchronizer compatibility with generator being used. Refer to procedure at beginning of this section.

Warm-up

a. The POWER switch (9) has two positions; STANDBY and ON. When instrument is switched to ON, a two-hour warm-up is required before the internal time base crystal oscillator has stabilized and is functioning to specification. However, if the instrument is equipped with Option 001 high stability time base, the two-hour warm-up applies to STANDBY time as well as ON time. If an external 1 MHz time base reference is used, the only warm-up required is that of the external source.

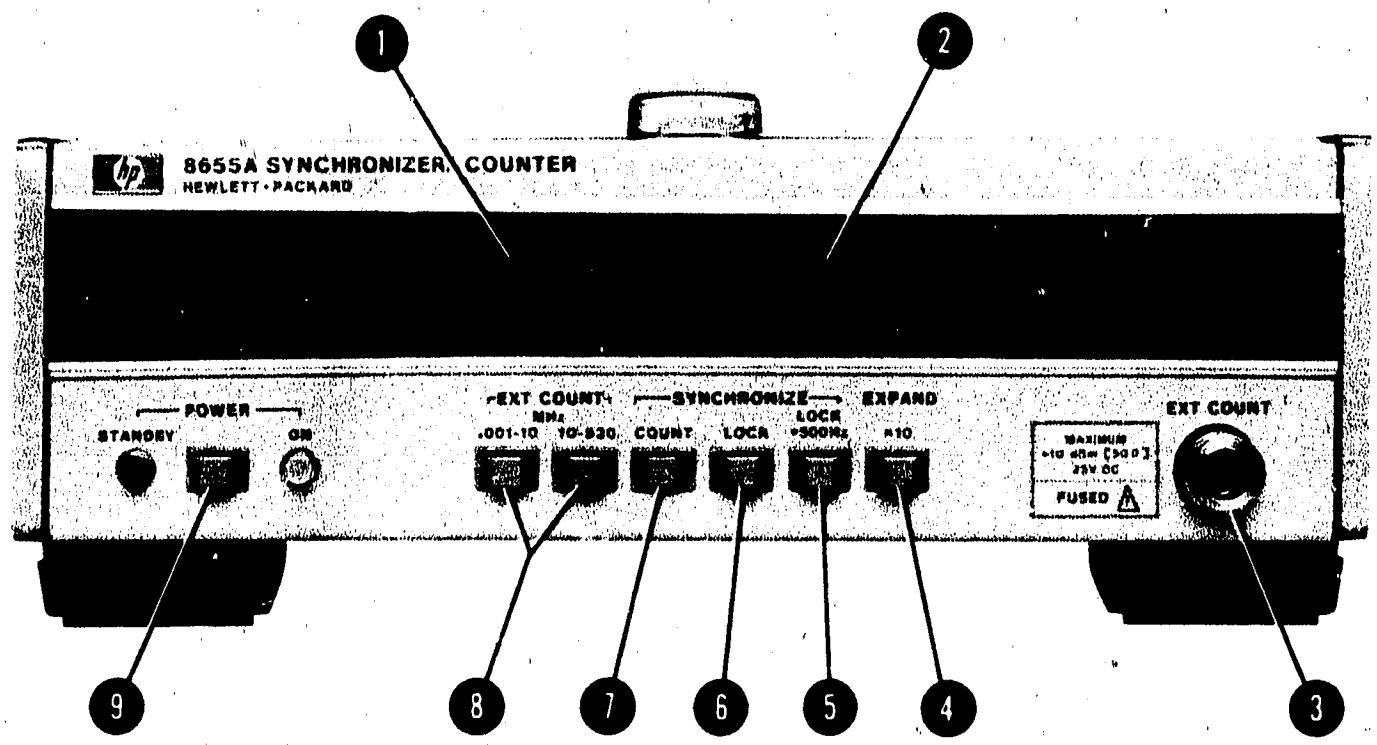
Time Base Selection

a. Set the rear panel TIME BASE switch to INT. The Synchronizer/Counter is referenced to its own internal crystal oscillator. A 1 MHz signal, typically > 0.5 Vp-p into 500Ω, is also present at the TIME BASE connector. This signal can be used as a common reference for other instruments in a test setup.

b. It is also possible to reference the Synchronizer/Counter to an externally applied 1 MHz standard (not possible when Option 001 is installed). Connect the external reference signal (1 MHz, > 0.5 Vp-p into 1000Ω) to the rear panel TIME BASE connector. Set TIME BASE switch to EXT.

Figure 3-4. Operating Instructions (1 of 5)

OPERATING INSTRUCTIONS



Counter

CAUTION

Do not apply >+10 dBm (707 mVrms into 50Ω) or > ±25 Vdc to front or rear panel RF inputs.

NOTE

Disconnect RF cable from front panel EXT COUNT connector (3) when it is not being used. A signal there can cause miscount or phase lock problems for signals entering rear panel RF IN.

a. The Frequency Display (2) always indicates frequency in megahertz. Decimal point location and display resolution is determined by the EXT COUNT MHz (8), SYNCHRONIZE COUNT (7) and EXPAND x 10 (4) buttons (see note).

Mode		Decimal Point	Resolution
EXT COUNT: .001—10 MHz	Normal EXPAND x 10	0.0 0 0 0 0 .0 0 0 0 0 0	10 Hz 1 Hz
EXT COUNT: 10—520 MHz	Normal EXPAND x 10	0 0 0.0 0 0 0 0.0 0 0 0	1 kHz 100 Hz
SYNCHRONIZE COUNT	Normal EXPAND x 10	0 0 0.0 0 0 0 0.0 0 0 0	1 kHz 100 Hz

Figure 3-4. Operating Instructions (2 of 5)

OPERATING INSTRUCTIONS

NOTE

The OVERFLOW indicator (1) will light whenever the signal frequency exceeds the display's capabilities. The displayed frequency will be correct except that the most significant digit is off the display.

b. Signals between 1 kHz and 10 MHz should be connected only to the front panel EXT COUNT connector (3). Depress EXT COUNT: .001—10 MHz button (8).

c. Signals between 10 and 520 MHz can be connected to either the EXT COUNT connector (3) or the rear panel RF IN connector. If connecting to EXT COUNT, depress EXT COUNT: 10—520 MHz button (8). If connecting to RF IN, depress SYNCHRONIZE COUNT button (7).

NOTES

EXT COUNT (8) and SYNCHRONIZE COUNT (7) switches are interlocked so that only one of the switches can be depressed at a time.

The front and rear RF inputs are protected by a common fuse. Refer to the RF Input Fuse replacement steps at the beginning of this section.

Phase Lock

CAUTION

Do not apply > +10 dBm (707 mVrms into 50Ω) or > ±25 Vdc to front or rear panel RF inputs.

NOTE

Disconnect RF cable from front panel EXT COUNT connector (3) when it is not being used. A signal there can cause miscount or phase lock problems for signals entering rear panel RF IN.

a. Ensure that the internal selector switches are set for compatibility with the signal generator being used. Only qualified service personnel should make this check. See procedure at beginning of this section.

b. Connect the Synchronizer/Counter to the signal generator as follows:
RF IN (rear panel) to generator's auxiliary RF output.

ϕ LOCK (rear panel) to generator's phase lock input (on 8654A Signal Generators, to FM INPUT with FM switch set to EXT).

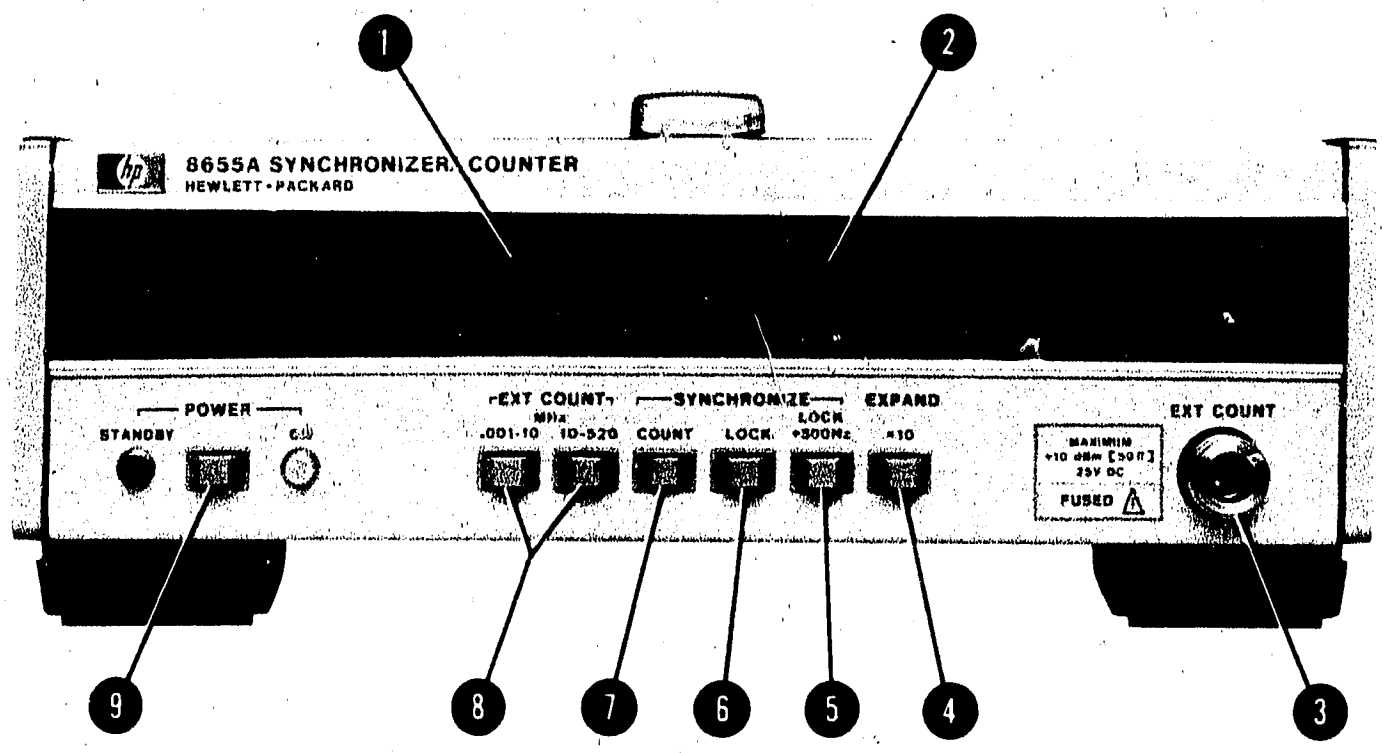
NOTES

If RFI leakage exceeds specified levels, carefully tighten RF Type N connectors with a pair of pliers.

Continued . . .

Figure 3-4. Operating Instructions (3 of 5)

OPERATING INSTRUCTIONS



NOTES (Cont'd)

The Synchronizer Counter can generally phase lock signals entering through the front panel EXT COUNT connector 3 *but it is not recommended. Ambiguity can arise in the 1 kHz to 10 MHz range. Phase lock is not specified, or possible over this entire range. Lock + 500 Hz is also not possible even though it is indicated by the extra digit (5) illuminated on the Frequency Display.*

c. With the Synchronizer/Counter in the count mode, set the generator's output to desired frequency as indicated on Frequency Display 2 . The last digit may be flickering between two numbers.

d. Press SYNCHRONIZER LOCK button 6 . The last digit should stop flickering and the generator's output will be phase locked at the displayed frequency.

e. Press SYNCHRONIZER LOCK + 500 Hz button 5 . A new least significant digit (5) should appear. The generator will respond with a phase locked output frequency 500 Hz greater than before (see following notes).

Figure 3-4. Operating Instructions (4 of 5)

OPERATING INSTRUCTIONS

NOTES

With either Lock button depressed, it is not possible to depress EXPAND x 10 (4) .

Do not apply FM signals with rates less than 50 Hz to the generator. Doing so could cause FM deviation to be uncalibrated (8654B) or the synchronizer to break phase lock (blinking display).

It is possible to enter phase lock directly with the LOCK + 500 Hz (5) *switch. The generator will then lock to a frequency 500 Hz greater than had been indicated in the count mode.*

f. Release the LOCK + 500 Hz button (5) . The last digit (5) will disappear from the display. The generator will respond by reverting to the original phase locked frequency.

g. Whenever phase lock is lost, the Frequency Display (2) will begin to blink at about a 2 Hz rate. The Synchronizer/Counter will revert to count mode and the display will indicate actual generator frequency. To reset phase lock, release LOCK button(s); retune to desired frequency and depress LOCK button(s) again.

Figure 3-4. Operating Instructions (5 of 5)

PERFORMANCE CHECK

SECTION IV
PERFORMANCE TESTS

WARNINGS

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

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

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this intrument dangerous. Intentional interruption is prohibited.

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

4-1. INTRODUCTION

4-2. The procedures in this section test the electrical performance of the Synchronizer/Counter using the specifications of Table 1-1 as the performance standards. All tests can be performed without access to the interior of the instrument. A simpler operational test is included in Section III under Operator's Checks.

4-3. EQUIPMENT REQUIRED

4-4. Equipment required for the performance tests is listed in the Recommended Test Equipment table in Section I. Any equipment that satisifies the critical specifications given in the table may be substituted for the recommended model(s).

4-5. TEST RECORD

4-6. Results of the performance tests may be tabulated on the Test Record at the end of this section. The Test Record lists all of the tested specifications and their acceptable limits. Test results recorded at incoming inspection can be used for comparison in periodic maintenance, troubleshooting, and after repairs or adjustments.

4-7. PERFORMANCE TESTS

4-8. The performance tests given in this section are suitable for incoming inspection, troubleshooting or preventative maintenance. During any performance test, all shields and connecting hardware must be in place. The tests are designed to verify published instrument specifications. Perform the tests in the order given and record the data on the test card and/or in the data spaces provided throughout each procedure.

NOTES

Unless otherwise specified, no warmup period is required for these tests.

Line voltage must be within +5%, −10% of nominal if the performance tests are to be considered valid.

4-9. The specifications are written as they appear in Table 1-1, Specifications. A description of the test and any special instructions or problem areas are included. Some tests that require test equipment have a setup drawing; and each has a list of the required equipment. The initial steps of each procedure give control settings required for that particular test.

PERFORMANCE TESTS

4-10. COUNTER SENSITIVITY AND RANGE TEST

SPECIFICATION: **Range:** 1 kHz to 520 MHz
Sensitivity: <100 mVrms (−7 dBm), ac coupled into 50 ohms.
Maximum Input: ac: 707 mVrms (+10 dBm) for accurate count

DESCRIPTION: A signal generator and test oscillator are used to test the counter's frequency range at both high and low levels on the low (1 kHz—10 MHz) and high (10—520 MHz) count input ranges.

EQUIPMENT:
Signal Generator . . . . . HP 8654A or 8654B
Test Oscillator . . . . . HP 651B

PROCEDURE:

1. Set Synchronizer/Counter controls as follows:

POWER	ON
EXT COUNT: 10—520 MHz	In
LOCK	Out
LOCK + 500 Hz	Out
EXPAND x 10	Out
TIME BASE (rear panel, except Option 001)	INT

2. Set RF signal generator to give a −7 dBm CW signal at 520 MHz.

3. Connect generator to front panel EXT COUNT input. Counter should read approximately 520 MHz.

Count: _____ (√)

4. Set generator to various frequencies between 520 MHz and 10 MHz (at −7 dBm). Counter reading should correspond approximately with generator's frequency indication.

Count: _____ (√)

5. Repeat step 4 for a generator output level of +10 dBm.

Count: _____ (√)

6. Set test oscillator to give a −7 dBm (into 50Ω) signal at 10 MHz.

7. Depress Synchronizer/Counter's EXT COUNT .001—10 MHz switch. Connect oscillator to front panel EXT COUNT input. Counter should read approximately 10 MHz.

Count: _____ (√)

8. Set oscillator to various frequencies between 10 MHz and 1 kHz (at −7 dBm). Counter reading should correspond approximatley with oscillator's frequency indication.

Count: _____ (√)

9. Repeat step 8 for oscillator level of +10 dBm.

Count: _____ (√)

PERFORMANCE TESTS

4-11. RF LEAKAGE TEST

SPECIFICATION: **RF leakage** (when operated with 8654B using furnished interface cables): Less than 1.5 μV in a 2-turn, 1-inch diameter loop, 1 inch away from any surface and measured into a 50-ohm receiver.

DESCRIPTION: A loop antenna is held one inch from all surfaces of the combined Synchronizer/Counter and signal generator. Any leakage is monitored with a spectrum analyzer. The loop is suspended in a molding so that when the tip of the molding is in contact with a surface, the loop antenna is one inch from the surface.

NOTES

The use of a screen room may be necessary to reduce interference from other sources.

Do not hold the antenna near the loop end while performing the test.

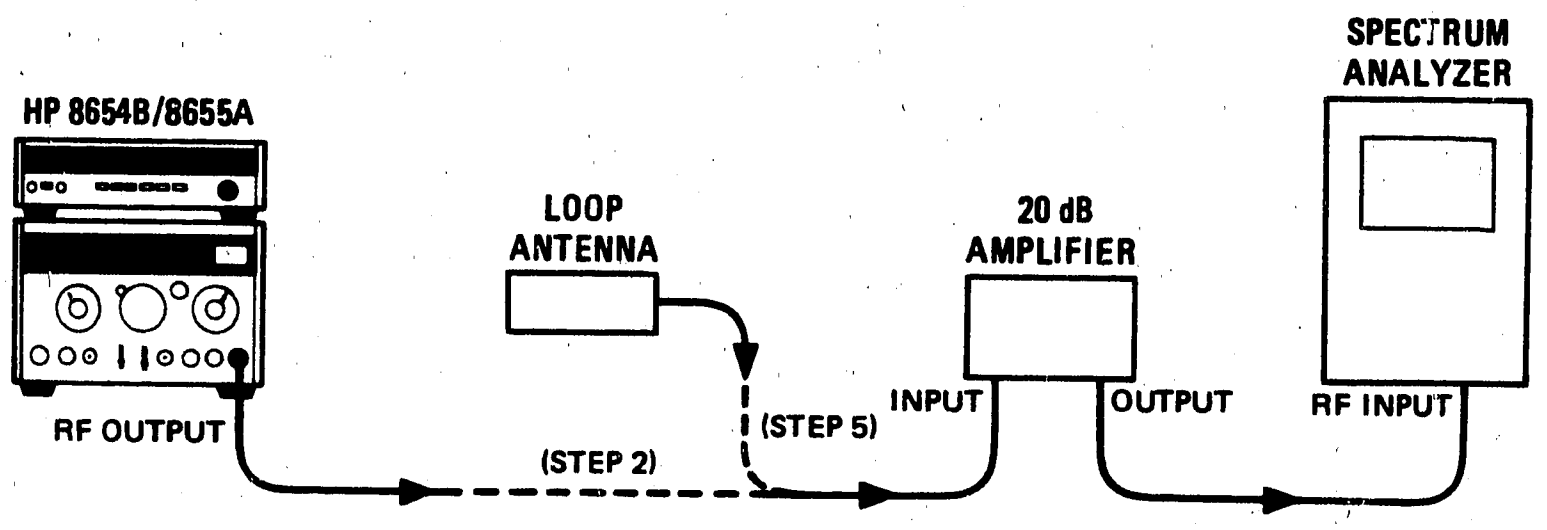


Figure 4-1. RF Leakage Test Setup

EQUIPMENT:

One-Inch Loop Antenna	HP 08640-60501
Signal Generator	HP 8654B
20 dB Amplifier	HP 8447A
Spectrum Analyzer	HP 8558B/182C
50 Ohm Load (2 required)	HP 11593A

PROCEDURE:

1. Interconnect Synchronizer/Counter and signal generator (see Section II). Be sure that rear panel Type N connections are secure.

2. Connect equipment as shown in Figure 4-1 (with signal generator connected to spectrum analyzer through amplifier). Set Synchronizer/Counter and signal generator controls as follows:

8654B:	METER	LEVEL
	FREQUENCY RANGE	66—130 MHz
	FREQUENCY TUNE	100 MHz
	OUTPUT LEVEL	—103 dBm
	AM	OFF
	FM	OFF

PERFORMANCE TESTS

4-11. RF LEAKAGE TEST (cont'd)

PROCEDURE: (cont'd)

8655A:

POWER	ON
SYNCHRONIZE COUNT	In
LOCK	Out
LOCK + 500 Hz	Out
EXPAND x 10	Out
TIME BASE (rear panel, except Option 001)	INT

3. Set spectrum analyzer resolution bandwidth to 30 kHz, optimum input level to −40 dBm (0 dB attenuation), frequency span to 50 kHz per division, vertical scale to 10 dB per division log, display smoothing to minimum (off), and center the frequency control to locate 100 MHz signal. Use vertical reference level control to set the signal to −40 dB graticule line on display.

4. Disconnect generator from analyzer and connect 50 ohm loads to generator's RF OUTPUT and Synchronizer/Counter EXT COUNT input.

5. Connect loop antenna to analyzer through amplifier. Hold the end of antenna cylinder in contact with various surfaces of the counter and generator and observe the display for the duration of a sweep. All signals and noise should be below −40 dB graticule line on display (i.e., less than −103 dBm or 1.5 μV) from 10 to 200 MHz.

_____ −40 dB (√)

6. Set analyzer center frequency control to 300 MHz and repeat step 5. All signals and noise should be below −40 dB graticule line on display from 200 to 400 MHz.

_____ −40 dB (√)

7. Set analyzer center frequency control to 400 MHz and repeat step 5. All signals and noise should be below −40 dB graticule line on display from 400 to 520 MHz.

_____ −40 dB (√)

Table 4-1. Performance Test Record

Hewlett-Packard
Model 8655A
Synchronizer/Counter

Tested By _____

Serial No.: _____

Date: _____

Paragraph No.	Test Description	Results		
		Min.	Actual	Max.
4-10.	**Counter Sensitivity and Range Test**			
	EXT COUNT 10—520 MHz:			
	—7 dBm (520 MHz)		_____	(√)
	—7 dBm (10—520 MHz)		_____	(√)
	+10 dBm (10—520 MHz)		_____	(√)
	EXT COUNT .001—10 MHz:			
	—7 dBm (10 MHz)		_____	(√)
	—7 dBm (1 kHz—10 MHz)		_____	(√)
	+10 dBm (1 kHz—10 MHz)		_____	(√)
4-11.	**RF Leakage Test**			
	10—200 MHz		_____	—40 dB (√)
	200—400 MHz		_____	—40 dB (√)
	400—520 MHz		_____	—40 dB (√)

ADJUSTMENTS

SECTION V
ADJUSTMENTS

WARNINGS

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

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

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

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

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

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

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

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

The front panel POWER switch does not have an off position. Whenever the power cord is connected between the instrument and a power source, hazardous voltage is present inside the instrument.

5-1. INTRODUCTION

5-2. This section describes the adjustments which will return the Synchronizer/Counter to peak operating condition. The adjustments are to be performed whenever performance test results are out of tolerance. This may occur over a period of time because of aging of components within the instrument or because of repair or replacement of certain components, parts or assemblies. Table 5-2 contains information pertaining to assemblies or parts repaired or replaced, performance tests which verify the instrument is performing to its maximum capability, and adjustments to be made if performance isn't at peak efficiency. Information is also provided in this section about the equipment required to perform the tests.

5-3. An adjustment procedure includes reference to service sheets where the adjustable components are shown, a description of the test including any problem areas or special instructions, a test equipment setup diagram (if necessary), test equipment recommended for the test, and a step-by-step procedure for performing the adjustments. Removal and installation procedures are presented on Service Sheets A and B located after schematics in Section 8. Adjustment locations are shown in photographs on Service Sheet B.

5-4. The following general information applies to all adjustments unless otherwise indicated.

a. No warm-up time is required.

b. Prior to any adjustment, check power supply voltages as indicated in paragraph 5-13.

c. After any adjustment, repeat the related tests indicated in Table 5-2 and perform the overall troubleshooting procedure in Section 8.

5-5. Leakage Test in Section 4 should be performed after any disassembly of the Counter/Lock casting or RF interconnect cables.

5-6. EQUIPMENT REQUIRED

5-7. The test equipment required for the adjustment procedures is listed in Table 1-2, Recommended Test Equipment. The critical specifications of substitute test instruments must meet or exceed the standards listed in the table if the performance of the generator is to meet the standards set forth in Table 1-1, Specifications.

5-8. FACTORY SELECTED COMPONENTS

5-9. A factory selected component is indicated on schematic and parts list by an asterisk (*). Only typical values are shown for selected parts. Table 5-1 lists factory selected components by reference designation, and contains the basis for selection, normal range of values and reference to appropriate service sheets. The yellow Manual Changes supplement may contain additional information about factory selected parts.

5-10. The following information supplements Table 5-1.

a. A1A1C4, C6, R2 and R3 Selection. Condition: replacing A1A1U1, U5 or U6 causes miscount to occur near high frequency limit (520 MHz) and near specified limits of input signal level (−7 or +10 dBm). Perform Counter Sensitivity and Range Test (paragraph 4-10, steps 1 thru 5 at 520 MHz only). If miscount occurs at −7 dBm, decrease value of R2 and increase R3 (see Table 5-1 for limits). If necessary, also decrease values of C4 and C6 equal amounts. If miscount occurs at +10 dBm, increase R2 and decrease R3, or increase both C4 and C6. Correcting for sensitivity can affect maximum input level and vice versa. Check both limits after making changes.

b. A1A2A1C10 Selection. Condition: changing components on A1A2A1 Counter/Lock Board Assembly causes indicated lock frequency to differ from actual frequency by one count near high frequency limit of instrument (e.g., 520.001 MHz instead of 520.000 MHz). Decrease value of C10.

c. A1A2A1C25 Selection. Condition: changing components on A1A2A1 Counter/Lock Board Assembly causes phase lock malfunction. Depress either LOCK or LOCK + 500 Hz button. Ground TP4 on A1A2A1 assembly (Service Sheet 5). Measure pulse width of TTL countdown signal at U23 pin 4 which should be between 20 and 40 ns (Service Sheet 4). If necessary, increase C25 to increase pulse width; decrease C25 to decrease pulse width.

5-11. RELATED REPAIRS, TESTS AND ADJUSTMENTS

5-12. Adjustments in this section should be performed when troubleshooting or performance tests indicate that an adjustable circuit is not operating correctly. Necessary Adjustments are listed in Table 5-2. After making an adjustment, repeat the tests indicated in the table and perform the overall troubleshooting procedure in Section 8.

NOTE

Table 5-2 can also be used for troubleshooting. If the instrument failed one or more performance tests, cross-referencing to the associated assembly or circuitry may indicate the source of the failure.

Table 5-1. Factory Selected Components

Reference Designation	Service Sheet	Normal Range of Values	Basis For Selection
A1A1C4 A1A1C6 A1A1R2 A1A1R3	3 3 3 3	0 to 10 pF (C4=C6) 0 to 10 pF 0 to 25Ω (R2+R3≈50Ω) 25 to 50Ω	Sensitivity and maximum input level at 520 MHz. See paragraph 5-10a.
A1A2A1C10	4	0 to 100 pF	Correct phase lock operation at 520 MHz. See paragraph 5-10b.
A1A2A1C25	4	0 to 100 pF	Correct phase lock operation. See paragraph 5-10c.

Table 5-2. Related Repairs, Performance Tests and Adjustment Procedures (1 of 2)

Assembly, Circuit or Part Repaired	Performance Test (After Repair Completed)	Adjustment Procedure (If Necessary)
All Electrical Repairs	Perform overall Troubleshooting procedure in Section 8.	Check Power Supply levels shown in paragraph 5-13.
A1	RF Leakage Test (4-11)	———
A1F1	RF Leakage Test (4-11)	———
A1A1	Counter Sensitivity and Range Test (4-10) RF Leakage Test (4-11)	Factory Selected Components (5-8)
A1A2A1 Up/Down Counter Circuits Only	RF Leakage Test (4-11)	Factory Selected Components (5-8)
A1A2A1 Null Phase Detector Circuits Only	RF Leakage Test (4-11)	Phase Lock Error Voltage Adjustment (5-14) Phase Lock Offset Adj.(5-15)
A1A3 Time Base Circuits Only	RF Leakage Test (4-11)	———
A1A3 Low-Pass Filter Circuits Only	RF Leakage Test (4-11)	Phase Lock Error Voltage Adjustment (5-14) Phase Lock Offset Adjustment (5-15)
A1A3Y1 (Standard Instrument)	RF Leakage Test (4-11)	Internal Time Base Reference Adjustment (5-16)
A2	See "All Electrical Repairs"	
A3	See "All Electrical Repairs"	

Table 5-2. Related Repairs, Performance Tests and Adjustment Procedures (2 of 2)

Assembly, Circuit or Part Repaired	Performance Test (After Repair Completed)	Adjustment Procedure (If Necessary)
A4 Power Supply Circuits Only	———	Power Supply Adjustment (5-13) Internal Time Base Reference Adjustment (5-16)
A4 Phase Lock Driver Circuits Only	———	Phase Lock Error Voltage Adjustment (5-14) Phase Lock Offset Adjustment (5-15)
A4 Fan Motor Driver Circuits	See "All Electrical Repairs"	
Y1 (Option 001)	———	Internal Time Base Reference Adjustment (5-16)

ADJUSTMENTS

5-13. POWER SUPPLY ADJUSTMENT

REFERENCE: Service Sheets 6 and B.

DESCRIPTION: A dc voltmeter is used to monitor the +20V, +5.2V, and −5.2V supply voltages as they are adjusted.

EQUIPMENT: Multimeter . . . . . HP 34702A/34740A

PROCEDURE:

1. Remove instrument bottom cover.
2. Set POWER to ON. Connect dc voltmeter to test points listed below. Adjust appropriate control to bring voltage to the listed level.

Supply	Test Point	Voltage Limits	Adjustment
+20V	A4TP1	+20.1 to +20.3Vdc	A4R18 20V ADJ
+5.2V	A4TP2	+5.15 to +5.25 Vdc	A4R20 +5V ADJ
-5.2V	A4TP3	-5.15 to -5.25 Vdc	A4R22 -5V ADJ

ADJUSTMENTS

5-14. PHASE LOCK ERROR VOLTAGE ADJUSTMENT

REFERENCE: Service Sheets 5 and B.

DESCRIPTION: With the instrument unlocked, the phase lock error voltage at A1A2A1TP6 is adjusted to be in the middle of the range of the error detector. This assures that the error detector breaks lock equally for positive or negative oscillator drifts.

EQUIPMENT: Multimeter . . . . . HP 34702A/34740A

PROCEDURE:

1. Set POWER to ON and EXT COUNT to 10-520 MHz (all other switches out).
2. Connect dc voltmeter to test point A1A2A1TP6. Adjust potentiometer A1A2A1R49 for voltmeter reading of +11.0 to +11.3 Vdc.

5-15. PHASE LOCK OFFSET ADJUSTMENT

REFERENCE: Service Sheets 5 and B.

DESCRIPTION: With the Synchronizer/Counter in a count mode, the phase lock tune voltage is set for 0 Vdc.

NOTE

Perform Phase Lock Error Voltage Adjustment (5-14) before starting this procedure.

EQUIPMENT: Multimeter . . . . . HP 34702A/34740A

PROCEDURE:

1. Remove instrument bottom cover.
2. Set controls as follows:

POWER	ON
SYNCHRONIZE COUNT	In
LOCK	Out
LOCK + 500 Hz	Out
EXPAND x 10	Out
A4S7 (internal)	8654A
A4S9 (internal)	8654

3. Connect dc voltmeter to A4TP6. Adjust A4R2 OFFSET for 0.00 ±0.02 Vdc as read on voltmeter.
4. Set A4S7 to 8654B. Voltmeter should read 0.00 ±0.05 Vdc.

ADJUSTMENTS

5-16. INTERNAL TIME BASE REFERENCE ADJUSTMENT

REFERENCE: Service Sheets 2 and B.

DESCRIPTION: An oscilloscope, triggered by an external reference, is used to set the internal reference frequency.

NOTE

A two hour warm-up is required for this adjustment (see step 2).

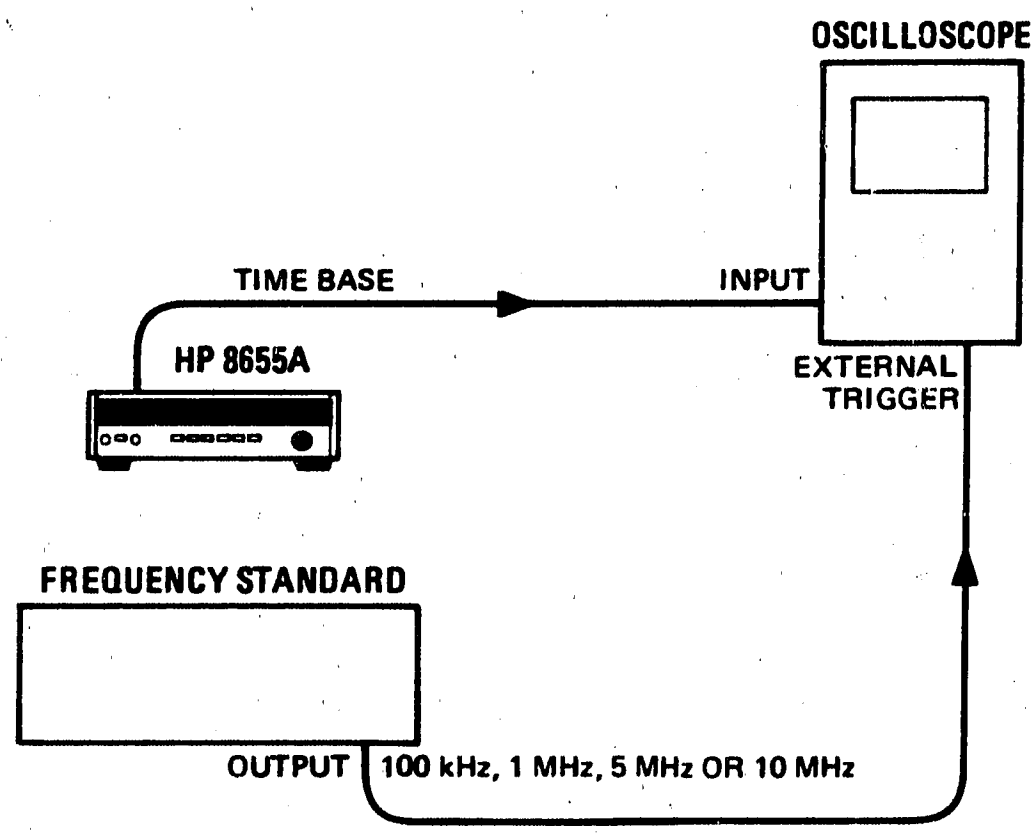


Figure 5-1. Time Base Reference Adjustment Setup

EQUIPMENT:

Frequency Standard	Suitable House Standard
Oscilloscope	HP 1820C/1801A/182C

PROCEDURE:

1. Remove front panel of standard instrument or right side cover of an Option 001.

2. Connect equipment as shown in Figure 5-1. Set Synchronizer/Counter's POWER switch to ON and rear panel TIME BASE switch to INT (standard model only). Allow equipment to warm up for two hours. (For Option 001 the warm-up is not required if the instrument has been energized in STANDBY mode for two hours or more.)

3. Set oscilloscope's vertical sensitivity to view time base output signal (typically >0.5 Vpp) and horizontal scale for 0.1 μs per division. Set oscilloscope trigger to external.

4. Adjust time base crystal for a stationary waveform. For the standard model remove the RFI shield on the front of the counter and adjust A1A3Y1. For Option 001 the adjustments for Y1 are situated on the right side of the instrument.

ADJUSTMENTS

5-16. INTERNAL TIME BASE REFERENCE ADJUSTMENT (Cont'd)

NOTE

Movement of the waveform one division per second to the right means that the generator's time base frequency is low by 0.1 part per million. Movement one division per second to left means time base frequency is high by 0.1 part per million.

5. Replace front panel or side cover.

PARTS LIST

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 6-2 lists all replaceable parts in reference designator order. Table 6-3 contains the names and addresses that correspond to the manufacturer's code numbers. Figure 6-1 shows front and rear views of the instrument and locations of external mechanical parts. (See Service Sheet A and B in Section 8 for locations of most internal mechanical parts.)

6-3. ABBREVIATIONS

6-4. Table 6-1 lists abbreviations used in the parts list, schematics and throughout the manual. In some cases, two forms of the abbreviations are used, one all in capital letters, and one partial or no capitals. This occurs because the abbreviations in the parts list (computer printout) are always all capitals. However, in the schematics and other parts of the manual, other abbreviation forms are used with both lower case and upper case letters.

6-5. REPLACEABLE PARTS LIST

6-6. Table 6-2 is the list of replaceable parts and is organized as follows:

a. Electrical assemblies and their components in alpha-numerical order by reference designation.

b. Chassis-mounted parts in alpha-numerical order by reference designation.

c. Miscellaneous parts.

d. Illustrated parts breakdowns, if appropriate.

The information given for each part consists of the following:

a. The Hewlett-Packard part number.

b. The total quantity (Qty) in the instrument.

c. The description of the part.

d. A typical manufacturer of the part in a five-digit code.

e. The manufacturer's number for the part.

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, quote 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, include the instrument model number, instrument serial number, the description and function of the part, and the number of parts required. Address the order to the nearest Hewlett-Packard office.

6-10. SPARE PARTS KIT

6-11. Stocking spare parts for an instrument is often done to ensure quick return to service after a malfunction occurs. Hewlett-Packard has a Spare Parts Kit available for this purpose. The kit consists of selected replaceable assemblies and components for this instrument. The contents of the kit and the Recommended Spares list are based on failure reports and repair data, and parts support for one year. A Recommended Spares list for this instrument may be obtained on request and the Spare Parts Kit may be ordered through your nearest Hewlett-Packard office.

6-12. DIRECT MAIL ORDER SYSTEM

6-13. Within the USA, Hewlett-Packard can supply parts through a direct mail order system. Advantages of using the system are as follows:

a. Direct ordering and shipment from the 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, check or money order must accompany each order.

6-14. Mail order forms and specific ordering information available through your local HP office. Addresses and phone numbers are located at the back of this manual.

Table 6-1. Reference Designations and Abbreviations (1 of 2)

REFERENCE DESIGNATIONS

A . . . . . assembly
AT . . attenuator; isolator; termination
B . . . . . fan; motor
BT . . . . . battery
C . . . . . capacitor
CP . . . . . coupler
CR . . . . . diode; diode thyristor; varactor
DC . . . directional coupler
DL . . . . . delay line
DS . . . . . annunciator; signaling device (audible or visual); lamp; LED
E . . . . . miscellaneous electrical part
F . . . . . fuse
FL . . . . . filter
H . . . . . hardware
HY . . . . . circulator
J . . . electrical connector (stationary portion); jack
K . . . . . relay
L . . . . . coil; inductor
M . . . . . meter
MP . . . . . miscellaneous mechanical part
P . . . electrical connector (movable portion); plug
Q . . . . . transistor; SCR; triode thyristor
R . . . . . resistor
RT . . . . . thermistor
S . . . . . switch
T . . . . . transformer
TB . . . . . terminal board
TC . . . . . thermocouple
TP . . . . . test point
U . . . . . integrated circuit; microcircuit
V . . . . . electron tube
VR . . . . voltage regulator; breakdown diode
W . . . . cable; transmission path; wire
X . . . . . socket
Y . . . . crystal unit (piezoelectric or quartz)
Z . . . . tuned cavity; tuned circuit

ABBREVIATIONS

A . . . . . ampere
ac . . . . alternating current
ACCESS . . . . . accessory
ADJ . . . . . adjustment
A/D . . . . analog-to-digital
AF . . . . . audio frequency
AFC . . . . . automatic frequency control
AGC . . . . . automatic gain control
AL . . . . . aluminum
ALC . . . . . automatic level control
AM . . . amplitude modulation
AMPL . . . . . amplifier
APC . . . . automatic phase control
ASSY . . . . . assembly
AUX . . . . . auxiliary
avg . . . . . average
AWG . . . . American wire gauge
BAL . . . . . balance
BCD . . . . . binary coded decimal
BD . . . . . board
BE CU . . . . . beryllium copper
BFO . . . . . beat frequency oscillator
BH . . . . . binder head
BKDN . . . . . breakdown
BP . . . . . bandpass
BPF . . . . . bandpass filter
BRS . . . . . brass
BWO . . . . . backward-wave oscillator
CAL . . . . . calibrate
ccw . . counter-clockwise
CER . . . . . ceramic
CHAN . . . . . channel
cm . . . . . centimeter
CMO . . cabinet mount only
COAX . . . . . coaxial
COEF . . . . . coefficient
COM . . . . . common
COMP . . . . . composition
COMPL . . . . . complete
CONN . . . . . connector
CP . . . . . cadmium plate
CRT . . . cathode-ray tube
CTL . . . . complementary transistor logic
CW . . . . . continuous wave
cw . . . . . clockwise
cm . . . . . centimeter
D/A . . . . digital-to-analog
dB . . . . . decibel
dBm . . . . decibel referred to 1 mW
dc . . . . . direct current
deg . . degree (temperature interval or difference)
° . . . . . degree (plane angle)
°C . . . . . degree Celsius (centigrade)
°F . . . . degree Fahrenheit
°K . . . . . degree Kelvin
DEPC . . deposited carbon
DET . . . . . detector
diam . . . . . diameter
DIA . . . diameter (used in parts list)
DIFF AMPL . . differential amplifier
div . . . . . division
DPDT . . . . . double-pole, double-throw
DR . . . . . drive
DSB . . . . double sideband
DTL . . . . diode transistor logic
DVM . . . digital voltmeter
ECL . . . . emitter coupled logic
EMF . . electromotive force
EDP . . . . . electronic data processing
ELECT . . . . . electrolytic
ENCAP . . . . encapsulated
EXT . . . . . external
F . . . . . farad
FET . . . . . field-effect transistor
F/F . . . . . flip-flop
FH . . . . . flat head
FIL H . . . . . fillister head
FM . . frequency modulation
FP . . . . . front panel
FREQ . . . . . frequency
FXD . . . . . fixed
g . . . . . gram
GE . . . . . germanium
GHz . . . . . gigahertz
GL . . . . . glass
GRD . . . . . ground(ed)
H . . . . . henry
h . . . . . hour
HET . . . . . heterodyne
HEX . . . . . hexagonal
HD . . . . . head
HDW . . . . . hardware
HF . . . . . high frequency
HG . . . . . mercury
HI . . . . . high
HP . . . . . Hewlett-Packard
HPF . . . . . high pass filter
HR . . . . . hour (used in parts list)
HV . . . . . high voltage
Hz . . . . . Hertz
IC . . . . integrated circuit
ID . . . . . inside diameter
IF . . . . . intermediate frequency
IMPG . . . . . impregnated
in . . . . . inch
INCD . . . . . incandescent
INCL . . . . . include(s)
INP . . . . . input
INS . . . . . insulation
INT . . . . . internal
kg . . . . . kilogram
kHz . . . . . kilohertz
kΩ . . . . . kilohm
kV . . . . . kilovolt
lb . . . . . pound
LC . . . . . inductance-capacitance
LED . . light-emitting diode
LF . . . . . low frequency
LG . . . . . long
LH . . . . . left hand
LIM . . . . . limit
LIN . . . linear taper (used in parts list)
lin . . . . . linear
LK WASH . . . lock washer
LO . . . low; local oscillator
LOG . . . . logarithmic taper (used in parts list)
log . . . . . logrithm(ic)
LPF . . . . . low pass filter
LV . . . . . low voltage
m . . . . . meter (distance)
mA . . . . . milliampere
MAX . . . . . maximum
MΩ . . . . . megohm
MEG . . . . meg (10^6) (used in parts list)
MET FLM . . . . metal film
MET OX . . metallic oxide
MF . . . medium frequency; microfarad (used in parts list)
MFR . . . . . manufacturer
mg . . . . . milligram
MHz . . . . . megahertz
mH . . . . . millihenry
mho . . . . . mho
MIN . . . . . minimum
min . . . . . minute (time)
. . .' . . . . . minute (plane angle)
MINAT . . . . . miniature
mm . . . . . millimeter

NOTE

All abbreviations in the parts list will be in upper-case.

Table 6-1. Reference Designations and Abbreviations (2 of 2)

MOD . . . . . modulator
MOM . . . . . momentary
MOS . . . . . metal-oxide semiconductor
ms . . . . . millisecond
MTG . . . . . mounting
MTR . . . meter (indicating device)
mV . . . . . millivolt
mVac . . . . . millivolt, ac
mVdc . . . . . millivolt, dc
mVpk . . . . millivolt, peak
mVp-p . . . millivolt, peak-to-peak
mVrms . . . . millivolt, rms
mW . . . . . milliwatt
MUX . . . . . multiplex
MY . . . . . mylar
μA . . . . . microampere
μF . . . . . microfarad
μH . . . . . microhenry
μmho . . . . . micromho
μs . . . . . microsecond
μV . . . . . microvolt
μVac . . . . . microvolt, ac
μVdc . . . . . microvolt, dc
μVpk . . . microvolt, peak
μVp-p . . . microvolt, peak-to-peak
μVrms . . . . microvolt, rms
μW . . . . . microwatt
nA . . . . . nanoampere
NC . . . . . no connection
N/C . . . . normally closed
NE . . . . . neon
NEG . . . . . negative
nF . . . . . nanofarad
NI PL . . . . . nickel plate
N/O . . . . . normally open
NOM . . . . . nominal
NORM . . . . . normal
NPN . . . negative-positive-negative
NPO . . . . negative-positive zero (zero temperature coefficient)
NRFR . . not recommended for field replacement
NSR . . . . . not separately replaceable
ns . . . . . nanosecond
nW . . . . . nanowatt
OBD . . . order by description
OD . . . . . outside diameter
OH . . . . . oval head
OP AMPL . . . operational amplifier
OPT . . . . . option
OSC . . . . . oscillator
OX . . . . . oxide
oz . . . . . ounce
Ω . . . . . ohm
P . . . . peak (used in parts list)
PAM . . . . pulse-amplitude modulation
PC . . . . . printed circuit
PCM . . pulse-code modulation; pulse-count modulation
PDM . . . . . pulse-duration modulation
pF . . . . . picofarad
PH BRZ phosphor bronze
PHL . . . . . Phillips
PIN . . . positive-intrinsic-negative
PIV . . . . . peak inverse voltage
pk . . . . . peak
PL . . . . . phase lock
PLO . . . . . phase lock oscillator
PM . . . . phase modulation
PNP . . . positive-negative-positive
P/O . . . . . part of
POLY . . . . . polystyrene
PORC . . . . . porcelain
POS . . positive; position(s) (used in parts list)
POSN . . . . . position
POT . . . . . potentiometer
p-p . . . . . peak-to-peak
PP . . . peak-to-peak (used in parts list)
PPM . . . . . pulse-position modulation
PREAMPL . . . preamplifier
PRF . . . . pulse-repetition frequency
PRR . . . . pulse repetition rate
ps . . . . . picosecond
PT . . . . . point
PTM . . . . . pulse-time modulation
PWM . . . . . pulse-width modulation
PWV . . . . . peak working voltage
RC . . . . . resistance-capacitance
RECT . . . . . rectifier
REF . . . . . reference
REG . . . . . regulated
REPL . . . . . replaceable
RF . . . . . radio frequency
RFI . . . . radio frequency interference
RH . . . . round head; right hand
RLC . . . . . resistance-inductance-capacitance
RMO . . . rack mount only
rms . . . . root-mean-square
RND . . . . . round
ROM . . read-only memory
R&P . . . . . rack and panel
RWV . . . reverse working voltage
S . . . scattering parameter
s . . . . . second (time)
. . . " . . second (plane angle)
S-B . . . . . slow-blow (fuse) (used in parts list)
SCR . . . silicon controlled rectifier; screw
SE . . . . . selenium
SECT . . . . . sections
SEMICON . . . . . semiconductor
SHF . . . . . superhigh frequency
SI . . . . . silicon
SIL . . . . . silver
SL . . . . . slide
SNR . . signal-to-noise ratio
SPDT . . . . . single-pole, double-throw
SPG . . . . . spring
SR . . . . . split ring
SPST . . . . . single-pole, single-throw
SSB . . . . . single sideband
SST . . . . . stainless steel
STL . . . . . steel
SQ . . . . . square
SWR . . standing-wave ratio
SYNC . . . . . synchronize
T . . timed (slow-blow fuse)
TA . . . . . tantalum
TC . . . . . temperature compensating
TD . . . . . time delay
TERM . . . . . terminal
TFT . . thin-film transistor
TGL . . . . . toggle
THD . . . . . thread
THRU . . . . . through
TI . . . . . titanium
TOL . . . . . tolerance
TRIM . . . . . trimmer
TSTR . . . . . transistor
TTL . . transistor-transistor logic
TV . . . . . television
TVI television interference
TWT . . traveling wave tube
U . . . . . micro (10^{-6}) (used in parts list)
UF . . . microfarad (used in parts list)
UHF . . ultrahigh frequency
UNREG . . . . unregulated
V . . . . . volt
VA . . . . . voltampere
Vac . . . . . volts, ac
VAR . . . . . variable
VCO . . . voltage-controlled oscillator
Vdc . . . . . volts, dc
VDCW . . volts, dc, working (used in parts list)
V(F) . . . . . volts, filtered
VFO . . variable-frequency oscillator
VHF . . . . . very-high frequency
Vpk . . . . . volts, peak
Vp-p . . volts, peak-to-peak
Vrms . . . . . volts, rms
VSWR . . . voltage standing wave ratio
VTO . . . . . voltage-tuned oscillator
VTVM . . . . vacuum-tube voltmeter
V(X) . . . . . volts, switched
W . . . . . watt
W/ . . . . . with
WIV . . . . working inverse voltage
WW . . . . . wirewound
W/O . . . . . without
YIG . . yttrium-iron-garnet
Z_o . . . . . characteristic impedance

NOTE

All abbreviations in the parts list will be in upper-case.

MULTIPLIERS

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

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1	08655-60010	1	COUNTER/LOCK ASSEMBLY (STANDARD)	28480	08655-60010
A1	08655-60014	1	COUNTER/LOCK ASSEMBLY (OPTION 001)	28480	08655-60014
A1C1	0160-2357	4	CAPACITOR-FXD 1000PF +80-20% 500WVDC CER	28480	0160-2357
A1C2	0160-2049	3	CAPACITOR-FXD 5000PF +80-20% 500WVDC CER	28480	0160-2049
A1C3	0160-2049		CAPACITOR-FXD 5000PF +80-20% 500WVDC CER	28480	0160-2049
A1C4	0160-2357		CAPACITOR-FXD 1000PF +80-20% 500WVDC CER	28480	0160-2357
A1C5	0160-2049		CAPACITOR-FXD 5000PF +80-20% 500WVDC CER	28480	0160-2049
A1C6	0160-2357		CAPACITOR-FXD 1000PF +80-20% 500WVDC CER	28480	0160-2357
A1C7	0160-2357		CAPACITOR-FXD 1000PF +80-20% 500WVDC CER	28480	0160-2357
A1F1	2110-0513	1	FUSE .125A 125V FAST-BLO .348X.25 UL (SEE SECTIONS I AND III)	75915	273.125
A1FL1	0160-0204	3	CAPACITOR-FLTR 5500PF CMV 200V	01121	SMFB-A2
A1FL2	0160-0204		CAPACITOR-FLTR 5500PF CMV 200V	01121	SMFB-A2
A1FL3	0160-0204		CAPACITOR-FLTR 5500PF CMV 200V	01121	SMFB-A2
A1L1	9100-2232	5	COIL-FXD MOLDED RF CHOKE .56UH 10%	24226	15/560
A1L2	9100-2232		COIL-FXD MOLDED RF CHOKE .56UH 10%	24226	15/560
A1L3	9100-2232		COIL-FXD MOLDED RF CHOKE .56UH 10%	24226	15/560
A1L4	9100-2232		COIL-FXD MOLDED RF CHOKE .56UH 10%	24226	15/560
A1L5	9100-2232		COIL-FXD MOLDED RF CHOKE .56UH 10%	24226	15/560
A1MP1	0361-0207	3	RIVET:BLIND, BLACK NYLON 0.125" DIA	00000	OBD
A1MP2	0362-0265	4	CONNECTOR CRIMP, INTERCONNECT WIRES	28480	0362-0265
A1MP3	0520-0127	3	SCREW-MACH 2-56 .188-IN-LG PAN-HD-POZI	28480	0520-0127
A1MP4	0570-0112	2	SCREW-MACH 0-80 .188-IN-LG FIL-HD-SLT	28480	0570-0112
A1MP5	1200-0081	2	INSULATOR-BSHG-FLG .115-ID	26365	974 307
A1MP6	1400-0249	1	CABLE TIE .062-.625-IN-DIA .091-IN-WD	06383	PLT1M-M-8
A1MP7	2190-0005	2	WASHER-LK EXT T NO.-4 .116-IN-ID	78189	1804-01
A1MP8	2190-0016	1	WASHER-LK INTL T NO.-3/8 .377-IN-ID	78189	1920-02
A1MP9	2190-0045		WASHER-LK HLCL NO.-2 .088-IN-ID	76854	1501-009
A1MP10	2190-0124	3	WASHER-LK INTL T NO.-10 .195-IN-ID	24931	LW101-30
A1MP11	2200-0103		SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	28480	2200-0103
A1MP12	2200-0105		SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0105
A1MP13	2200-0109	2	SCREW-MACH 4-40 .438-IN-LG PAN-HD-POZI	28480	2200-0109
A1MP14	2200-0111	4	SCREW-MACH 4-40 .5-IN-LG PAN-HD-POZI	28480	2200-0111
A1MP15	2200-0113	3	SCREW-MACH 4-40 .625-IN-LG PAN-HD-POZI	28480	2200-0113
A1MP16	2200-0119	4	SCREW-MACH 4-40 1-IN-LG PAN-HD-POZI	28480	2200-0119
A1MP17	2200-0151	2	SCREW-MACH 4-40 .75-IN-LG PAN-HD-POZI	28480	2200-0151
A1MP18	2200-0164		SCREW-MACH 4-40 .188-IN-LG 82 DEG	28480	2200-0164
A1MP19	2200-0165		SCREW-MACH 4-40 .25-IN-LG 82 DEG	28480	2200-0165
A1MP20	2950-0001	1	NUT-HEX-DBL-CHAM 3/8-32-THD .094-THK	12697	20/4-13
A1MP21	2950-0078	3	NUT-HEX-DBL-CHAM 10-32-THD .067-THK	24931	HN100-11
A1MP22	3050-0443	2	WASHER-FL NM NO.-8 .176-IN-ID .375-IN-OD	86928	5624-16-10
A1MP23	8150-0454		WIRE 24AWG V 300V PVC 7X32 80C	28480	8150-0454
A1MP24	8150-0455		WIRE 24AWG GY 300V PVC 7X32 80C	28480	8150-0455
A1MP25	8150-0456		WIRE 24AWG W 300V PVC 7X32 80C	28480	8150-0456
A1MP26	8160-0219	1	RFI STRIP NI ALY 1.06-W 2.64-L	28480	8160-0219
A1MP27	8160-0220	1	RFI STRIP NI ALY 2.48-W 4.215-L	28480	8160-0220
A1MP28	08640-00009	1	COVER, CENTER FILTER	28480	08640-00009
A1MP29	08640-00051	1	FRAME C SHIELD, LARGE	28480	08640-00051
A1MP30	08640-00096	1	INSULATOR, COUNTER HEAT	28480	08640-00096
A1MP31	08640-20059	1	COVER, CNTR INPUT	28480	08640-20059
A1MP32	08640-20060	1	HEAT SINK, CNTR	28480	08640-20060
A1MP33	08640-20089	2	SUPPORT, PC BOARD, CNTR	28480	08640-20089
A1MP34	08640-40041	1	PIPE, LIGHT GFLOW	28480	08640-40041
A1MP35	08655-00007	1	DUCT	28480	08655-00007
A1MP36	08655-00010	1	SHIELD, L.E.D.	28480	08655-00010
A1MP37	08655-00018	1	PLATE, COVER	28480	08655-00018
A1MP38	08655-20014	1	END PLUG-COUNTER	28480	08655-20014
A1MP39	08655-20018	1	COVER, COUNTER TOP	28480	08655-20018
A1MP40	08655-20019	1	COVER, COUNTER, BOTTOM	28480	08655-20019
A1MP41	08655-20025	1	SHIELD, FUSE	28480	08655-20025
A1MP42	08655-20026	1	CAP, FUSE	28480	08655-20026
A1MP43	08655-20030	1	FILTER, WINDOW	28480	08655-20030
A1U1	----------		NOT ASSIGNED		
A1U2	1820-1003	1	IC COUNTER	28480	1820-1003
A1U3	1990-0462	7	DISPLAY NUM DOT MAT 1 CHAR .29 IN HIGH	28480	1990-0462
A1U4	1990-0462		DISPLAY NUM DOT MAT 1 CHAR .29 IN HIGH	28480	1990-0462
A1U5	1990-0462		DISPLAY NUM DOT MAT 1 CHAR .29 IN HIGH	28480	1990-0462
A1U6	1990-0462		DISPLAY NUM DOT MAT 1 CHAR .29 IN HIGH	28480	1990-0462
A1U7	1990-0462		DISPLAY NUM DOT MAT 1 CHAR .29 IN HIGH	28480	1990-0462
A1U8	1990-0462		DISPLAY NUM DOT MAT 1 CHAR .29 IN HIGH	28480	1990-0462
A1U9	1990-0462		DISPLAY NUM DOT MAT 1 CHAR .29 IN HIGH	28480	1990-0462

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1A1	08655-60001	1	RF SCALER BOARD ASSEMBLY (DOES NOT INCLUDE FUSE A1F1 OR A1U2)	28480	08655-60001
A1A1C1	0160-0127	1	CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
A1A1C2	0160-3879	6	CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A1A1C3	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A1A1C4*	0160-3873	2	CAPACITOR-FXD 4.7PF +-.5PF 200WVDC CER *(SELECTED PART, SEE SECTION VI)	28480	0160-3873
A1A1C5	0180-0197	16	CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	1500225X9020A2
A1A1C6*	0160-3873		CAPACITOR-FXD 4.7PF +-.5PF 200WVDC CER *(SELECTED PART, SEE SECTION VI)	28480	0160-3873
A1A1C7	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A1A1C8	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A1A1C9	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A1A1C10	0160-0572	1	CAPACITOR-FXD 2200PF +-20% 100WVDC CER	28480	0160-0572
A1A1CR1	1901-0050	3	DIODE-SWITCHING 80V 200MA 2NS DO-7	28480	1901-0050
A1A1CR2	1901-0050		DIODE-SWITCHING 80V 200MA 2NS DO-7	28480	1901-0050
A1A1CR3	1901-0050		DIODE-SWITCHING 80V 200MA 2NS DO-7	28480	1901-0050
A1A1J1	1250-1220	2	CONNECTOR-RF SMC M PC	98291	50-051-0109
A1A1J2	1250-1220		CONNECTOR-RF SMC M PC	98291	50-051-0100
A1A1K1	0490-0633	1	RELAY 6VDC CONT 1A 350VDC FORM 2C	28480	0490-0633
A1A1MP1	1251-1998	12	CONNECTOR-SGL CONT SKT .025-DIA	28480	1251-1998
A1A1MP2	1251-1998		CONNECTOR-SGL CONT SKT .025-DIA	28480	1251-1998
A1A1MP3	3050-0079	6	WASHER-FL MM NO.-2 .094-IN-ID .188-IN-OD	23050	2
A1A1MP4	1251-1556	5	CONNECTOR-SGL CONT SKT .04-DIA	28480	1251-1556
A1A1Q1	1854-0345	1	TRANSISTOR NPN 2N5179 SI TO-72 PD=200MW	04713	2N5179
A1A1Q2	1854-0404	2	TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A1A1Q3	1854-0404		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0404
A1A1R1	0698-7205	5	RESISTOR 51.1 2% .05W F TC=0+-100	24546	C3-1/8-T00-51R1-G
A1A1R2*	0698-7188	1	RESISTOR 10 2% .05W F TC=0+-100 *(SELECTED PART, SEE SECTION VI)	24546	C3-1/8-T00-10R-G
A1A1R3*	0698-7203	1	RESISTOR 42.2 2% .05W F TC=0+-100 *(SELECTED PART, SEE SECTION VI)	24546	C3-1/8-T00-42R2-G
A1A1R4	0698-7205		RESISTOR 51.1 2% .05W F TC=0+-100	24546	C3-1/8-T00-51R1-G
A1A1R5	0698-7205		RESISTOR 51.1 2% .05W F TC=0+-100	24546	C3-1/8-T00-51R1-G
A1A1R6	0698-7205		RESISTOR 51.1 2% .05W F TC=0+-100	24546	C3-1/8-T00-51R1-G
A1A1R7	0698-3152	1	RESISTOR 3.48K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3481-F
A1A1R8	0698-7229	4	RESISTOR 511 2% .05W F TC=0+-100	24546	C3-1/8-T0-511R-G
A1A1R9	0698-7236	3	RESISTOR 1K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1001-G
A1A1R10	0698-7205		RESISTOR 51.1 2% .05W F TC=0+-100	24546	C3-1/8-T00-51R1-G
A1A1R11	0698-7201	2	RESISTOR 34.8 2% .05W F TC=0+-100	24546	C3-1/8-T00-34R8-G
A1A1R12	0698-7227	1	RESISTOR 422 2% .05W F TC=0+-100	24546	C3-1/8-T0-422R-G
A1A1R13	0698-7240	4	RESISTOR 1.47K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1471-G
A1A1R14	0698-7229		RESISTOR 511 2% .05W F TC=0+-100	24546	C3-1/8-T0-511R-G
A1A1R15	0698-7284	3	RESISTOR 100K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1003-G
A1A1R16	0698-7240		RESISTOR 1.47K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1471-G
A1A1R17	0698-7240		RESISTOR 1.47K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1471-G
A1A1R18	0698-7201		RESISTOR 34.8 2% .05W F TC=0+-100	24546	C3-1/8-T00-34R8-G
A1A1R19	0698-7222	1	RESISTOR 261 2% .05W F TC=0+-100	24546	C3-1/8-T0-261R-G
A1A1R20	0698-7240		RESISTOR 1.47K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1471-G
A1A1U1	1820-0736	1	IC COUNTER	28480	1820-0736
A1A1U2	----------		NOT ASSIGNED		
A1A1U3	1820-0145	1	IC MC 1010P GATE	04713	MC1010P
A1A1U4	1820-0817	1	IC MC10131P FLIP-FLOP	04713	MC10131P
A1A1U5	1820-0982	2	IC 5084-0164 DIFF AMPL	28480	1820-0982
A1A1U6	1820-0982		IC 5084-0164 DIFF AMPL	28480	1820-0982
A1A1A1	08655-60033	1	ISOLATION BOARD ASSEMBLY	28480	08655-60033
A1A1A1C1	0160-0571	2	CAPACITOR-FXD 470PF +-20% 100WVDC CER	28480	0160-0571
A1A1A1C2	0160-0571		CAPACITOR-FXD 470PF +-20% 100WVDC CER	28480	0160-0571
A1A1A1CR1	1901-0639	1	DIODE-PIN 110V	28480	1901-0639
A1A1A1L1	9100-2251	2	COIL-FXD MOLDED RF CHOKE .22UH 10%	24226	10/220
A1A1A1L2	9100-2251		COIL-FXD MOLDED RF CHOKE .22UH 10%	24226	10/220
A1A1A1R1	0698-7219	3	RESISTOR 196 2% .05W F TC=0+-100	24546	C3-1/8-T0-196R-G
A1A1A1R2	0698-7219		RESISTOR 196 2% .05W F TC=0+-100	24546	C3-1/8-T0-196R-G
A1A2	----------		COUNTER/DISPLAY ASSEMBLY (INCLUDES A1A2A1 AND A1A2A2 ASSEMBLIES)		
A1A2A1	08655-60003	1	COUNTER/LOCK BOARD ASSEMBLY	28480	08655-60003

See introduction to this section for ordering information

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1A2A1C1	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A2A1C2	0160-3879		CAPACITOR-FXD .01UF +-20% 100WVDC CER	28480	0160-3879
A1A2A1C3	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A2A1C4	0160-2055	18	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A2A1C5	0180-0291	4	CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150C105X9035A2
A1A2A1C6	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A2A1C7	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A2A1C8	0180-0228	2	CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A1A2A1C9	0180-0228		CAPACITOR-FXD 22UF+-10% 15VDC TA	56289	150D226X9015B2
A1A2A1C10*	0160-2204	1	CAPACITOR-FXD 100PF +-5% 300WVDC MICA *(SELECTED PART, SEE SECTION V)	28480	0160-2204
A1A2A1C11	0160-3455	3	CAPACITOR-FXD 470PF +-10% 1000WVDC CER	28480	0160-3455
A1A2A1C12	0160-3455		CAPACITOR-FXD 470PF +-10% 1000WVDC CER	28480	0160-3455
A1A2A1C13	0160-2207	1	CAPACITOR-FXD 300PF +-5% 300WVDC MICA	28480	0160-2207
A1A2A1C14	0160-3877	3	CAPACITOR-FXD 100PF +-20% 200WVDC CER	28480	0160-3877
A1A2A1C15	0160-3455		CAPACITOR-FXD 470PF +-10% 1000WVDC CER	28480	0160-3455
A1A2A1C16	0160-3456	4	CAPACITOR-FXD 1000PF +-10% 1000WVDC CER	28480	0160-3456
A1A2A1C17	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A2A1C18	0160-3094	14	CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A2A1C19	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A2A1C20	0180-0049	1	CAPACITOR-FXD 20UF+75-10% 50VDC AL	56289	30D206G050CC2
A1A2A1C21	0160-3456		CAPACITOR-FXD 1000PF +-10% 1000WVDC CER	28480	0160-3456
A1A2A1C22	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A2A1C23	0180-1735	1	CAPACITOR-FXD .22UF+-10% 35VDC TA	56289	150D224X9035A2
A1A2A1C24	0160-3456		CAPACITOR-FXD 1000PF +-10% 1000WVDC CER	28480	0160-3456
A1A2A1C25*	0160-2201	1	CAPACITOR-FXD 51PF +-5% 300WVDC MICA *(SELECTED PART, SEE SECTION V)	28480	0160-2201
A1A2A1CR1	1901-0040	12	DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1A2A1CR2	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1A2A1J1	---------		CONSISTS OF 36 SOCKETS LISTED BELOW		
	1200-0448	36	SOCKET-IC 1-CONT DIP-SLDR-TERMS	27264	1938-4G1
A1A2A1L1	9100-1622	1	COIL-FXD MOLDED RF CHOKE 24UH 5%	24226	15/242
A1A2A1L2	9100-1618	1	COIL-FXD MOLDED RF CHOKE 5.6UH 10%	24226	15/561
A1A2A1Q1	1854-0071	11	TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q2	1853-0020	5	TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A1A2A1Q3	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A1A2A1Q4	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q5	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q6	1855-0062	3	TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0062
A1A2A1Q7	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A1A2A1Q8	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q9	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q10	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q11	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q12	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q13	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A1A2A1Q14	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q15	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1Q16	----------		NOT ASSIGNED		
A1A2A1Q17	----------		NOT ASSIGNED		
A1A2A1Q18	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A1A2A1R1	0698-7236		RESISTOR 1K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1001-G
A1A2A1R2	0757-0442	10	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1A2A1R3	0811-1662	1	RESISTOR .47 5% 2W PW TC=0+-800	75042	BWH2-47/100-J
A1A2A1R4	0757-0279	1	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3161-F
A1A2A1R5	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1A2A1R6	0698-3440	1	RESISTOR 196 1% .125W F TC=0+-100	16299	C4-1/8-T0-196R-F
A1A2A1R7	0698-0083	6	RESISTOR 1.96K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1961-F
A1A2A1R8	0698-0083		RESISTOR 1.96K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1961-F
A1A2A1R9	0698-0083		RESISTOR 1.96K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1961-F
A1A2A1R10	0757-0416	6	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1A2A1R11	0698-7229		RESISTOR 511 2% .05W F TC=0+-100	24546	C3-1/8-T0-511R-G
A1A2A1R12	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1A2A1R13	0698-7236		RESISTOR 1K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1001-G
A1A2A1R14	0698-7219		RESISTOR 196 2% .05W F TC=0+-100	24546	C3-1/8-T0-196R-G
A1A2A1R15	0698-7253	4	RESISTOR 5.11K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5111-G
A1A2A1R16	0698-7253		RESISTOR 5.11K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5111-G
A1A2A1R17	0698-7239	2	RESISTOR 1.33K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1331-G
A1A2A1R18	0698-7258	2	RESISTOR 8.25K 2% .05W F TC=0+-100	24546	C3-1/8-T0-8251-G
A1A2A1R19	0698-7260	4	RESISTOR 10K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1002-G
A1A2A1R20	0698-7239		RESISTOR 1.33K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1331-G

See introduction to this section for ordering information

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1A2A1R21	0698-7260		RESISTOR 10K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1002-G
A1A2A1R22	0698-7243	1	RESISTOR 1.96K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1961-G
A1A2A1R23	0698-7229		RESISTOR 511 2% .05W F TC=0+-100	24546	C3-1/8-T0-511R-G
A1A2A1R24	0698-7277	5	RESISTOR 51.1K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5112-G
A1A2A1R25	0698-7277		RESISTOR 51.1K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5112-G
A1A2A1R26	0698-7264	1	RESISTOR 14.7K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1472-G
A1A2A1R27	0698-7246	2	RESISTOR 2.61K 2% .05W F TC=0+-100	24546	C3-1/8-T0-2611-G
A1A2A1R28	0698-7246		RESISTOR 2.61K 2% .05W F TC=0+-100	24546	C3-1/8-T0-2611-G
A1A2A1R29	0683-8245	2	RESISTOR 820K 5% .25W FC TC=-800/+900	01121	CB8245
A1A2A1R30	0683-8245		RESISTOR 820K 5% .25W FC TC=-800/+900	01121	CB8245
A1A2A1R31	0757-0438	3	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1A2A1R32	0698-7267	2	RESISTOR 19.6K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1962-G
A1A2A1R33	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1A2A1R34	0698-7272	1	RESISTOR 31.6K 2% .05W F TC=0+-100	24546	C3-1/8-T0-3162-G
A1A2A1R35	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1A2A1R36	0698-7277		RESISTOR 51.1K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5112-G
A1A2A1R37	0698-7288	1	RESISTOR 147K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1473-G
A1A2A1R38	0698-7277		RESISTOR 51.1K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5112-G
A1A2A1R39	0698-7267		RESISTOR 19.6K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1962-G
A1A2A1R40	0698-7284		RESISTOR 100K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1003-G
A1A2A1R41	0698-7284		RESISTOR 100K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1003-G
A1A2A1R42	0698-3453	1	RESISTOR 196K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1963-F
A1A2A1R43	0698-7260		RESISTOR 10K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1002-G
A1A2A1R44	0698-7277		RESISTOR 51.1K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5112-G
A1A2A1R45	0698-7253		RESISTOR 5.11K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5111-G
A1A2A1R46	0698-7253		RESISTOR 5.11K 2% .05W F TC=0+-100	24546	C3-1/8-T0-5111-G
A1A2A1R47	0698-3442	1	RESISTOR 237 1% .125W F TC=0+-100	16299	C4-1/8-T0-237R-F
A1A2A1R48	0698-3266	1	RESISTOR 237K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2373-F
A1A2A1R49	2100-2497	2	RESISTOR-TRMR 2K 10% C TOP-ADJ 1-TURN	19701	ET50W202
A1A2A1R50	0698-7258		RESISTOR 8.25K 2% .05W F TC=0+-100	24546	C3-1/8-T0-8251-G
A1A2A1R51	0698-7260		RESISTOR 10K 2% .05W F TC=0+-100	24546	C3-1/8-T0-1002-G
A1A2A1R52	0698-7256	1	RESISTOR 6.81K 2% .05W F TC=0+-100	24546	C3-1/8-T0-6811-G
A1A2A1TP1	0360-1514	13	TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A1A2A1TP2	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A1A2A1TP3	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A1A2A1TP4	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A1A2A1TP5	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A1A2A1TP6	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A1A2A1U1	1820-0077	3	IC SN74 74 N FLIP-FLOP	01295	SN7474N
A1A2A1U2	1820-0054	5	IC SN74 00 N GATE	01295	SN7400N
A1A2A1U3	1820-0054		IC SN74 00 N GATE	01295	SN7400N
A1A2A1U4	1820-0174	2	IC SN74 04 N INV	01295	SN7404N
A1A2A1U5	1820-0077		IC SN74 74 N FLIP-FLOP	01295	SN7474N
A1A2A1U6	1820-1322	2	IC SN74S 02 N GATE	01295	SN74S02N
A1A2A1U7	1820-0701	6	IC LATCH	07263	93L14DC
A1A2A1U8	1820-0701		IC LATCH	07263	93L14DC
A1A2A1U9	1820-0701		IC LATCH	07263	93L14DC
A1A2A1U10	1820-0701		IC LATCH	07263	93L14DC
A1A2A1U11	1820-0701		IC LATCH	07263	93L14DC
A1A2A1U12	1820-0701		IC LATCH	07263	93L14DC
A1A2A1U13	1820-0511	3	IC SN74 08 N GATE	01295	SN7408N
A1A2A1U14	1820-0205	2	IC MC 3003P GATE	04713	MC3003P
A1A2A1U15	1820-0054		IC SN74 00 N GATE	01295	SN7400N
A1A2A1U16	1820-0054		IC SN74 00 N GATE	01295	SN7400N
A1A2A1U17	1820-0511		IC SN74 08 N GATE	01295	SN7408N
A1A2A1U18	1820-0511		IC SN74 08 N GATE	01295	SN7408N
A1A2A1U19	1820-0546	7	IC SN74 192 N COUNTER	01295	SN74192N
A1A2A1U20	1820-0546		IC SN74 192 N COUNTER	01295	SN74192N
A1A2A1U21	1820-0546		IC SN74 192 N COUNTER	01295	SN74192N
A1A2A1U22	1820-0546		IC SN74 192 N COUNTER	01295	SN74192N
A1A2A1U23	1820-0546		IC SN74 192 N COUNTER	01295	SN74192N
A1A2A1U24	1820-0546		IC SN74 192 N COUNTER	01295	SN74192N
A1A2A1U25	1820-1322		IC SN74S 02 N GATE	01295	SN74S02N
A1A2A1U26	1820-0077		IC SN74 74 N FLIP-FLOP	01295	SN7474N
A1A2A1U27	1820-0205		IC MC 3003P GATE	04713	MC3003P
A1A2A1U28	1820-0546		IC SN74 192 N COUNTER	01295	SN74192N
A1A2A1U29	1826-0092	1	IC MC 1458 OP AMP	28480	1826-0092
A1A2A1VR1	1902-3070	1	DIODE-ZNR 4.22V 5% DO-7 PD=.4W TC=-.038%	04713	SZ 10939-74
A1A2A1VR2	1902-3182	1	DIODE-ZNR 12.1V 5% DO-7 PD=.4W TC=+.064%	04713	SZ 10939-206
A1A2A2	08655-60009	1	DISPLAY SOCKET BOARD ASSEMBLY (DOES NOT INCLUDE NUMERIC DISPLAYS A1U3 THRU A1U9)	28480	08655-60009

See introduction to this section for ordering information

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1A2A2DS1	2140-0016	1	LAMP-INCAND T-1 BULB 5V	00501	11-AS25
A1A2A2J1A	1200-0595	2	SOCKET-IC 28-CONT DIP-SLDR-TERMS	28480	1200-0595
A1A2A2J1B	1200-0595		SOCKET-IC 28-CONT DIP-SLDR-TERMS	28480	1200-0595
A1A2A2MP1	03431-01201	3	FOOT	28480	03431-01201
A1A2A2MP2	03431-01201		FOOT	28480	03431-01201
A1A2A2MP3	03431-01201		FOOT	28480	03431-01201
A1A2A2P1A	1260-0363	1	CONNECTOR:11 PIN	28480	1260-0363
A1A2A2P1B	1260-0364	1	CONNECTOR:25 PIN	28480	1260-0364
A1A3	08655-60008	1	TIME BASE BOARD ASSEMBLY (STANDARD, OR ORDER 08655-60013 FOR BOARD WITHOUT CRYSTAL A1A3Y1)	28480	08655-60008
A1A3	08655-60013	1	TIME BASE BOARD ASSEMBLY (OPTION 001)	28480	08655-60013
A1A3C1	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C2	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C3	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C4	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C5	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C6	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C7	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C8	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C9	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C10	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C11	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C12	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C13	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C14	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C15	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C16	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C17	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C18	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C19	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C20	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C21	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C22	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A1A3C23	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C24	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C25	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C26	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C27	0160-3877		CAPACITOR-FXD 100PF +-20% 200WVDC CER	28480	0160-3877
A1A3C28	0160-3877		CAPACITOR-FXD 100PF +-20% 200WVDC CER	28480	0160-3877
A1A3C29	0160-3456		CAPACITOR-FXD 1000PF +-10% 1000WVDC CER	28480	0160-3456
A1A3C30	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C31	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C32	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C33	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C34	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3C35	0180-0100	1	CAPACITOR-FXD 4.7UF+-10% 35VDC TA	56289	150D475X903582
A1A3C36	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A1A3C37	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A1A3C38	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A1A3C39	0160-3094		CAPACITOR-FXD .1UF +-10% 100WVDC CER	28480	0160-3094
A1A3CR1	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1A3CR2	1901-0518	1	DIODE-SCHOTTKY	28480	1901-0518
A1A3CR3	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1A3CR4	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1A3CR5	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A1A3J1	1250-1383	1	CONNECTOR-RF SM SNP M SGL HOLE RR	28480	1250-1383
A1A3J2	--------		NSR, P/O ETCHED CIRCUIT BOARD		
A1A3L1	9140-0137	5	COIL-FXD MOLDED RF CHOKE 1MH 5%	24226	19/104
A1A3L2	9140-0137		COIL-FXD MOLDED RF CHOKE 1MH 5%	24226	19/104
A1A3L3	9140-0137		COIL-FXD MOLDED RF CHOKE 1MH 5%	24226	19/104
A1A3L4	08640-80001	4	FILTER, TOROID	28480	08640-80001
A1A3L5	08640-80001		FILTER, TOROID	28480	08640-80001
A1A3L6	9140-0237	1	COIL-FXD MOLDED RF CHOKE 200UH 5%	24226	15/203
A1A3L7	08640-80001		FILTER, TOROID	28480	08640-80001
A1A3L8	08640-80001		FILTER, TOROID	28480	08640-80001
A1A3L9	9140-0137		COIL-FXD MOLDED RF CHOKE 1MH 5%	24226	19/104
A1A3L10	9140-0137		COIL-FXD MOLDED RF CHOKE 1MH 5%	24226	19/104
A1A3MP1	1251-0600	9	CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3MP2	1251-0600		CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3MP3	1251-0600		CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3MP4	08640-20211	8	GUIDE, CONNECTOR	28480	08640-20211
A1A3MP5	08640-20211		GUIDE, CONNECTOR	28480	08640-20211

See introduction to this section for ordering information

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1A3MP6	3050-0079		WASHER-FL NM NO.-2 .094-IN-ID .188-IN-OD	23050	2
A1A3MP7	3050-0079		WASHER-FL NM NO.-2 .094-IN-ID .188-IN-OD	23050	2
A1A3MP8	3050-0079		WASHER-FL NM NO.-2 .094-IN-ID .188-IN-OD	23050	2
A1A3MP9	3050-0079		WASHER-FL NM NO.-2 .094-IN-ID .188-IN-OD	23050	2
A1A3MP10	3050-0079		WASHER-FL NM NO.-2 .094-IN-ID .188-IN-OD	23050	2
A1A3Q1	1855-0062		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0062
A1A3Q2	1855-0062		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0062
A1A3Q3	1854-0023	2	TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0023
A1A3Q4	1854-0019	1	TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0019
A1A3Q5	1854-0023		TRANSISTOR NPN SI TO-18 PD=360MW	28480	1854-0023
A1A3Q6	1853-0007	1	TRANSISTOR PNP 2N3251 SI TO-18 PD=360MW	04713	2N3251
A1A3R1	0757-0399	5	RESISTOR 82.5 1% .125W F TC=0+-100	24546	C4-1/8-T0-82R5-F
A1A3R2	0698-3155	5	RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A1A3R3	0757-0399		RESISTOR 82.5 1% .125W F TC=0+-100	24546	C4-1/8-T0-82R5-F
A1A3R4	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A1A3R5	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A1A3R6	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1A3R7	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A1A3R8	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1A3R9	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1A3R10	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1A3R11	0698-0085	1	RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A1A3R12	0698-0083		RESISTOR 1.96K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1961-F
A1A3R13	0698-3450	1	RESISTOR 42.2K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4222-F
A1A3R14	0698-0083		RESISTOR 1.96K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1961-F
A1A3R15	0698-0083		RESISTOR 1.96K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1961-F
A1A3R16	0698-3447	1	RESISTOR 422 1% .125W F TC=0+-100	16299	C4-1/8-T0-422R-F
A1A3R17	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1A3R18	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A1A3R19	0757-0399		RESISTOR 82.5 1% .125W F TC=0+-100	24546	C4-1/8-T0-82R5-F
A1A3R20	0698-3437	4	RESISTOR 133 1% .125W F TC=0+-100	16299	C4-1/8-T0-133R-F
A1A3R21	0698-3444	3	RESISTOR 316 1% .125W F TC=0+-100	16299	C4-1/8-T0-316R-F
A1A3R22	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1A3R23	0757-0280	1	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A1A3R24	0757-0399		RESISTOR 82.5 1% .125W F TC=0+-100	24546	C4-1/8-T0-82R5-F
A1A3R25	0757-0399		RESISTOR 82.5 1% .125W F TC=0+-100	24546	C4-1/8-T0-82R5-F
A1A3R26	0757-0465	3	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A1A3R27	0757-0447	1	RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A1A3R28	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1A3R29	0698-3260	1	RESISTOR 464K 1% .125W F TC=0+-100	03888	PME55S
A1A3R30	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1A3R31	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A1A3TP1	1251-0600		CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3TP2	1251-0600		CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3TP3	1251-0600		CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3TP4	1251-0600		CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3TP5	1251-0600		CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3TP6	1251-0600		CONTACT-CONN U/W POST TYPE MALE DPSLDR	28480	1251-0600
A1A3U1	1820-0661	1	IC SN74 32 N GATE	01295	SN7432N
A1A3U2	1820-0174		IC SN74 04 N INV	01295	SN7404N
A1A3U3	1820-0054		IC SN74 00 N GATE	01295	SN7400N
A1A3U4	1820-0579	1	IC SN74 123 N MV	01295	SN74123N
A1A3U5	1820-1429	2	IC SN74LS160 N COUNTER	01295	SN74LS160N
A1A3U6	1820-1429		IC SN74LS160 N COUNTER	01295	SN74LS160N
A1A3U7	1820-1490	4	IC SN74LS 90 N COUNTER	01295	SN74LS90N
A1A3U8	1820-1490		IC SN74LS 90 N COUNTER	01295	SN74LS90N
A1A3U9	1820-1490		IC SN74LS 90 N COUNTER	01295	SN74LS90N
A1A3U10	1820-1490		IC SN74LS 90 N COUNTER	01295	SN74LS90N
A1A3U11	1820-0055	1	IC SN74 90 N COUNTER	01295	SN7490N
A1A3XA1A4	1251-2035	2	CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-300
A1A3Y1	1813-0063	1	CRYSTAL OSCILLATOR (STANDARD)	28480	1813-0063
A1A4	08640-60028	1	RISER BOARD ASSEMBLY	28480	08640-60028
A1A4XA1A2A1	1251-2035		CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS	71785	252-15-30-300
A2	08655-60007	1	FILTER BOARD ASSEMBLY	28480	08655-60007
A2C1	0180-2181	1	CAPACITOR-FXD 1300UF+75-10% 50VDC AL	56289	36D132G050AA2A
A2C2	0180-0540	1	CAPACITOR-FXD 8400UF+75-10% 30VDC AL	00853	500842U030AB2B
A2C3	0180-0484	1	CAPACITOR-FXD 4500UF+75-10% 25VDC AL	56289	36DX452G025AA2B-DQB

See introduction to this section for ordering information

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2MP1	2190-0034	6	WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
A2MP2	2190-0034		WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
A2MP3	2190-0034		WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
A2MP4	2190-0034		WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
A2MP5	2190-0034		WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
A2MP6	2190-0034		WASHER-LK HLCL NO.-10 .194-IN-ID	28480	2190-0034
A2MP7	2680-0128		SCREW-MACH 10-32 .25-IN-LG PAN-HD-POZI	28480	2680-0128
A2MP8	2680-0128		SCREW-MACH 10-32 .25-IN-LG PAN-HD-POZI	28480	2680-0128
A2MP9	2680-0128		SCREW-MACH 10-32 .25-IN-LG PAN-HD-POZI	28480	2680-0128
A2MP10	2680-0128		SCREW-MACH 10-32 .25-IN-LG PAN-HD-POZI	28480	2680-0128
A2MP11	2680-0128		SCREW-MACH 10-32 .25-IN-LG PAN-HD-POZI	28480	2680-0128
A2MP12	2680-0128		SCREW-MACH 10-32 .25-IN-LG PAN-HD-POZI	28480	2680-0128
A2R1	0757-0833	1	RESISTOR 5.11K 1% .5W F TC=0+-100	19701	MF7C1/2-T0-5111-F
A2R2	0757-0817	2	RESISTOR 750 1% .5W F TC=0+-100	19701	MF7C1/2-T0-751-F
A2R3	0757-0817		RESISTOR 750 1% .5W F TC=0+-100	19701	MF7C1/2-T0-751-F
A3	08655-60011	1	FAN MOTOR ASSEMBLY	28480	08655-60011
A3B1	----------		MOTOR, 10 VDC (NRFR)		
A3A1	----------		FAN MOTOR BOARD ASSEMBLY (NRFR)		
A3A1J1	1200-0508	2	SOCKET-IC 14-CONT DIP-SLDR-TERMS	06776	ICN-143-S3W
A4	08655-60006	1	POWER SUPPLY//CONTROL BOARD ASSEMBLY (DOES NOT /NCLUDE FUSES F1 THRU F3 OR REGULATORS U1 THRU U3)	28480	08655-60006
A4C1	0160-3878	1	CAPACITOR-FXD 1000PF +-20% 100WVDC CER	28480	0160-3878
A4C2	0180-2207	2	CAPACITOR-FXD 100UF+-10% 10VDC TA	56289	150D107X9010R2
A4C3	0180-2207		CAPACITOR-FXD 100UF+-10% 10VDC TA	56289	150D107X9010R2
A4C4	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A4C5	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C6	---------		NOT ASSIGNED		
A4C7	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C8	0160-2055		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-2055
A4C9	0160-4084	1	CAPACITOR-FXD .1UF +-20% 50WVDC CER	28480	0160-4084
A4C10	0180-0291		CAPACITOR-FXD 1UF+-10% 35VDC TA	56289	150D105X9035A2
A4C11	0180-0197		CAPACITOR-FXD 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A4C12	0180-2215	1	CAPACITOR-FXD 170UF+75-10% 15VDC AL	56289	30D177G015DD2
A4C13	0180-0116	1	CAPACITOR-FXD 6.8UF+-10% 35VDC TA	56289	150D685X9035B2
A4C14	0180-2208	2	CAPACITOR-FXD 220UF+-10% 10VDC TA	56289	150D227X9010S2
A4C15	0180-2208		CAPACITOR-FXD 220UF+-10% 10VDC TA	56289	150D227X9010S2
A4CR1	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR2	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR3	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR4	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR5	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR6	1901-0040		DIODE-SWITCHING 30V 50MA 2NS DO-35	28480	1901-0040
A4CR7	1901-0159	5	DIODE-PWR RECT 400V 750MA DO-41	04713	SR1358-4
A4CR8	1901-0159		DIODE-PWR RECT 400V 750MA DO-41	04713	SR1358-4
A4CR9	1901-0159		DIODE-PWR RECT 400V 750MA DO-41	04713	SR1358-4
A4CR10	1901-0200	7	DIODE-PWR RECT 100V 1.5A	04713	SR1846-9
A4CR11	1901-0200		DIODE-PWR RECT 100V 1.5A	04713	SR1846-9
A4CR12	1901-0159		DIODE-PWR RECT 400V 750MA DO-41	04713	SR1358-4
A4CR13	1901-0159		DIODE-PWR RECT 400V 750MA DO-41	04713	SR1358-4
A4CR14	1901-0200		DIODE-PWR RECT 100V 1.5A	04713	SR1846-9
A4CR15	1901-0200		DIODE-PWR RECT 100V 1.5A	04713	SR1846-9
A4CR16	1901-0200		DIODE-PWR RECT 100V 1.5A	04713	SR1846-9
A4CR17	1901-0200		DIODE-PWR RECT 100V 1.5A	04713	SR1846-9
A4CR18	1901-0200		DIODE-PWR RECT 100V 1.5A	04713	SR1846-9
A4DS1	1990-0485	3	LED-VISIBLE	28480	1990-0485
A4DS2	1990-0485		LED-VISIBLE	28480	1990-0485
A4DS3	1990-0485		LED-VISIBLE	28480	1990-0485
A4J1	1250-0835	1	CONNECTOR-RF SMC M PC	24931	37JR104-2
A4J2	---------		NSR, P/O ETCHED CIRCUIT BOARD		
A4J3	---------		NSR, P/O ETCHED CIRCUIT BOARD		
A4J4	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A4J5	1200-0508		SOCKET-IC 14-CONT DIP-SLDR-TERMS	06776	ICN-143-S3W
A4MP1	0363-0110	2	CONTACT, LAMP	28480	0363-0110
A4MP2	0363-0110		CONTACT, LAMP	28480	0363-0110
A4MP3	0380-0043	1	STANDOFF-RVT-ON .375LG .141D .250D BRS	28480	0380-0043
A4MP4	0380-0383	6	STANDOFF-RVT-ON .125LG 6-32THD .250D BRS	28480	0380-0383
A4MP5	0380-0383		STANDOFF-RVT-ON .125LG 6-32THD .250D BRS	28480	0380-0383

See introduction to this section for ordering information

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4MP6	0380-0383		STANDOFF-RVT-ON .125LG 6-32THD .2500 BRS	28480	0380-0383
A4MP7	0380-0383		STANDOFF-RVT-ON .125LG 6-32THD .2500 BRS	28480	0380-0383
A4MP8	0380-0383		STANDOFF-RVT-ON .125LG 6-32THD .2500 BRS	28480	0380-0383
A4MP9	0380-0383		STANDOFF-RVT-ON .125LG 6-32THD .2500 BRS	28480	0380-0383
A4MP10	0380-0641	2	STANDOFF-RND .425LG 2-56THD .13600 BRS	28480	0380-0641
A4MP11	0380-0641		STANDOFF-RND .425LG 2-56THD .13600 BRS	28480	0380-0641
A4MP12	1251-1998		CONNECTOR-SGL CONT SKT .025-DIA	28480	1251-1998
A4MP13	1251-2313	6	CONNECTOR-SGL CONT SKT .04-DIA	00779	3-332070-5
A4MP14	08640-20211		GUIDE, CONNECTOR	28480	08640-20211
A4MP15	08640-20211		GUIDE, CONNECTOR	28480	08640-20211
A4MP16	08655-00006	1	INSULATOR, PB(6 SWITCHES)	28480	08655-00006
A4MP17	08655-00015	1	INSULATOR, PB(1 SWITCH)	28480	08655-00015
A4Q1	1884-0012	2	THYRISTOR-SCR JEDEC 2N3528	02735	2N3528
A4Q2	1884-0012		THYRISTOR-SCR JEDEC 2N3528	02735	2N3528
A4Q3	1853-0027	4	TRANSISTOR PNP SI TO-39 PD=1W FT=100MHZ	28480	1853-0027
A4Q4	1853-0027		TRANSISTOR PNP SI TO-39 PD=1W FT=100MHZ	28480	1853-0027
A4Q5	1853-0027		TRANSISTOR PNP SI TO-39 PD=1W FT=100MHZ	28480	1853-0027
A4Q6	1853-0027		TRANSISTOR PNP SI TO-39 PD=1W FT=100MHZ	28480	1853-0027
A4Q7	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A4Q8	1854-0045	1	TRANSISTOR NPN SI TO-18 PD=500MW	28480	1854-0045
A4R1	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-TO-5111-F
A4R2	2100-2497		RESISTOR-TRMR 2K 10% C TOP-ADJ 1-TURN	19701	ET50W202
A4R3	0757-0428	1	RESISTOR 1.62K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1621-F
A4R4	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1003-F
A4R5	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1002-F
A4R6	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1003-F
A4R7	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1002-F
A4R8	0757-0418	1	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-TO-619R-F
A4R9	0757-0317	1	RESISTOR 1.33K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1331-F
A4R10	0757-0290	2	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-TO-6191-F
A4R11	0757-0290		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-TO-6191-F
A4R12	0683-0335	1	RESISTOR 3.3 5% .25W FC TC=-400/+500	01121	CB33G5
A4R13	0698-3444		RESISTOR 316 1% .125W F TC=0+-100	16299	C4-1/8-TO-316R-F
A4R14	0698-3444		RESISTOR 316 1% .125W F TC=0+-100	16299	C4-1/8-TO-316R-F
A4R15	0757-0401	4	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-TO-101-F
A4R16	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-TO-101-F
A4R17	0757-0159	1	RESISTOR 1K 1% .5W F TC=0+-100	19701	MF1C1/2-TO-1R0-F
A4R18	2100-2061	1	RESISTOR-TRMR 200 10% C TOP-ADJ 1-TURN	30983	ET50W201
A4R19	0757-0795	2	RESISTOR 75 1% .5W F TC=0+-100	19701	MF-1/2-TO-75R0-F
A4R20	2100-2010	2	RESISTOR-TRMR 10 20% C TOP-ADJ 1-TURN	32997	3329H-1-10R
A4R21	0757-0795		RESISTOR 75 1% .5W F TC=0+-100	19701	MF-1/2-TO-75R0-F
A4R22	2100-2010		RESISTOR-TRMR 10 20% C TOP-ADJ 1-TURN	32997	3329H-1-10R
A4R23	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-TO-101-F
A4R24	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-TO-101-F
A4R25	0698-3437		RESISTOR 133 1% .125W F TC=0+-100	16299	C4-1/8-TO-133R-F
A4R26	0698-3437		RESISTOR 133 1% .125W F TC=0+-100	16299	C4-1/8-TO-133R-F
A4R27	0698-3437		RESISTOR 133 1% .125W F TC=0+-100	16299	C4-1/8-TO-133R-F
A4S1	3101-1730	1	SWITCH-PUSHBUTTON 15MM C-C SPACING (INCLUDES A4S2 AND A4S3)	28480	3101-1730
A4S2	--------		NSR, P/O S1		
A4S3	--------		NSR, P/O S1		
A4S4	3101-2035	1	SWITCH-PUSHBUTTON 3-STATION (INCLUDES A4S5 AND A4S6)	28480	3101-2035
A4S5	--------		NSR, P/O S4		
A4S6	--------		NSR, P/O S4		
A4S7	3101-0973	2	SWITCH-SL DPDT-NS MINTR .5A 125VAC/DC PC	79727	GF126-0018
A4S8	3101-2031	1	SWITCH-PUSHBUTTON SINGLE STATION	28480	3101-2031
A4S9	3101-0973		SWITCH-SL DPDT-NS MINTR .5A 125VAC/DC PC	79727	GF126-0018
A4TP1	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A4TP2	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A4TP3	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A4TP4	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A4TP5	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A4TP6	0360-1514		TERMINAL-STUD SGL-PIN PRESS-MTG	28480	0360-1514
A4U1	----------		NOT ASSIGNED		
A4U2	----------		NOT ASSIGNED		
A4U3	----------		NOT ASSIGNED		
A4U4	1826-0013	2	IC OP AMP	28480	1826-0013
A4U5	1826-0013		IC OP AMP	28480	1826-0013

See introduction to this section for ordering information

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4VR1	1902-0041	1	DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
A4VR2	1902-0049	2	DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	04713	SZ 10939-122
A4VR3	1902-0049		DIODE-ZNR 6.19V 5% DO-7 PD=.4W TC=+.022%	04713	SZ 10939-122
A4VR4	1902-0202	1	DIODE-ZNR 15V 5% DO-15 PD=1W TC=+.057%	28480	1902-0202
A4XA1	---------		NOT ASSIGNED		
A4XA2	1251-0472	1	CONNECTOR-PC EDGE 6-CONT/ROW 2-ROWS	71785	252-06-30-300
A5	0960-0444	1	LINE MODULE(INCLUDES A5J1 AND A5P1, DOES NOT INCLUDE FUSE F4)	28480	0960-0444
A5J1	---------		NSP, P/O A5		
A5P1	5020-8157	1	CARD VOLTAGE SELECT, (SEE SECTION II)	28480	5020-8157
			CHASSIS PARTS		
DS1	2140-0259	2	LAMP-INCAND T-1 BULB 12V (SEE SECTION III)	71744	CM32
DS2	2140-0259		LAMP-INCAND T-1 BULB 12V (SEE SECTION III)	71744	CM32
F1	2110-0520	3	FUSE 5A 125V FAST-BLO .348X.25 UL (SEE SECTION I)	75915	273005
F2	2110-0520		FUSE 5A 125V FAST-BLO .348X.25 UL (SEE SECTION I)	75915	273005
F3	2110-0520		FUSE 5A 125V FAST-BLO .348X.25 UL (SEE SECTION I)	75915	273005
F4	2110-0007	1	FUSE 1A 250V SLO-BLO 1.25X.25 UL (FOR 100-120V OPERATION,SEE SEC.III)	71400	MDL-1
F4	2110-0360	1	FUSE .75A 250V SLO-BLO 1.25X.25 UL IEC (FOR 220-240V OPERATION,SEE SEC.I & III)	71400	MDL.750
J1	---------		NSR, P/O W1 (STANDARD)		
J1	---------		NSR, P/O W7(OPTION 001)		
J2	---------		NSR, P/O W2		
J3	---------	1	CONNECTOR ASSEMBLY,EXT COUNT FRONT (SEE FIGURE 6-2)	28480	08655-60020
J4	---------		NSR, P/O W4		
MP	---------		FOR MECHANICAL PARTS, SEE PAGE 6-14		
P1	5060-0109	1	CONNECTOR ASSEMBLY, 15 CONTACT	28480	5060-0109
P2	0362-0265		CONNECTOR,CRIMP, TIME BASE SWITCH(STD)	28480	0362-0265
P3	---------		NSR, P/O W1 (STANDARD)		
P3	---------		NSR, P/O W8 (OPTION 001)		
P4	---------		NSR, P/O W7(OPTION 001)		
P5	---------		NSR, P/O W8 (OPTION 001)		
S1	3101-0070	1	SWITCH-SL DPDT-NS MINTR .5A 125VAC/DC	79727	GF-126-0000
T1	9100-0673	1	TRANSFORMER	28480	9100-0673
U1	1826-0126	1	IC V RGLTR	07263	7818KC
	1200-0043	3	INSULATOR-XSTR TO-3 .02-THK	76530	322047
	08655-20017	6	BUSHING, INSULATOR	28480	08655-20017
	08655-20017		BUSHING, INSULATOR	28480	08655-20017
U2	1826-0181	1	IC LM 323 V RGLTR	27014	LM323K
	1200-0043		INSULATOR-XSTR TO-3 .02-THK	76530	322047
	08655-20017		BUSHING, INSULATOR	28480	08655-20017
	08655-20017		BUSHING, INSULATOR	28480	08655-20017
U3	1826-0202	1	IC LM 320 V RGLTR	27014	LM320K-05
	1200-0043		INSULATOR-XSTR TO-3 .02-THK	76530	322047
	08655-20017		BUSHING, INSULATOR	28480	08655-20017
	08655-20017		BUSHING, INSULATOR	28480	08655-20017
W1	08655-60005	1	CABLE ASSEMBLY, TIME BASE (STANDARD, INCLUDES J1, P3 AND MP48)	28480	08655-60005
W2	08655-20024	1	CABLE ASSEMBLY, RF IN REAR(INCLUDES J2)	28480	08655-20024
W3	08655-20023	1	CABLE ASSEMBLY, EXT COUNT FRONT	28480	08655-20023
W4	08655-60004	1	CABLE ASSEMBLY, PHASE LOCK (INCLUDES J4 AND MP48)	28480	08655-60004
W5	8120-1378	1	CABLE ASSEMBLY, LINE POWER (SEE SECTION I AND II)	28480	8120-1378
W6	08655-60002	1	CABLE ASSEMBLY, FAN MOTOR	28480	08655-60002
W7	08655-60017	1	CABLE ASSEMBLY, TB/OUTPUT(OPTION 001, INCLUDES J1 AND P4)	28480	08655-60017
W8	08655-60015	1	CABLE ASSEMBLY, TB/COUNTER (OPTION 001, INCLUDES P3 AND P5)	28480	08655-60015
Y1	0960-2128	1	CRYSTAL OSCILLATOR (OPTION 001)	28480	0960-2128

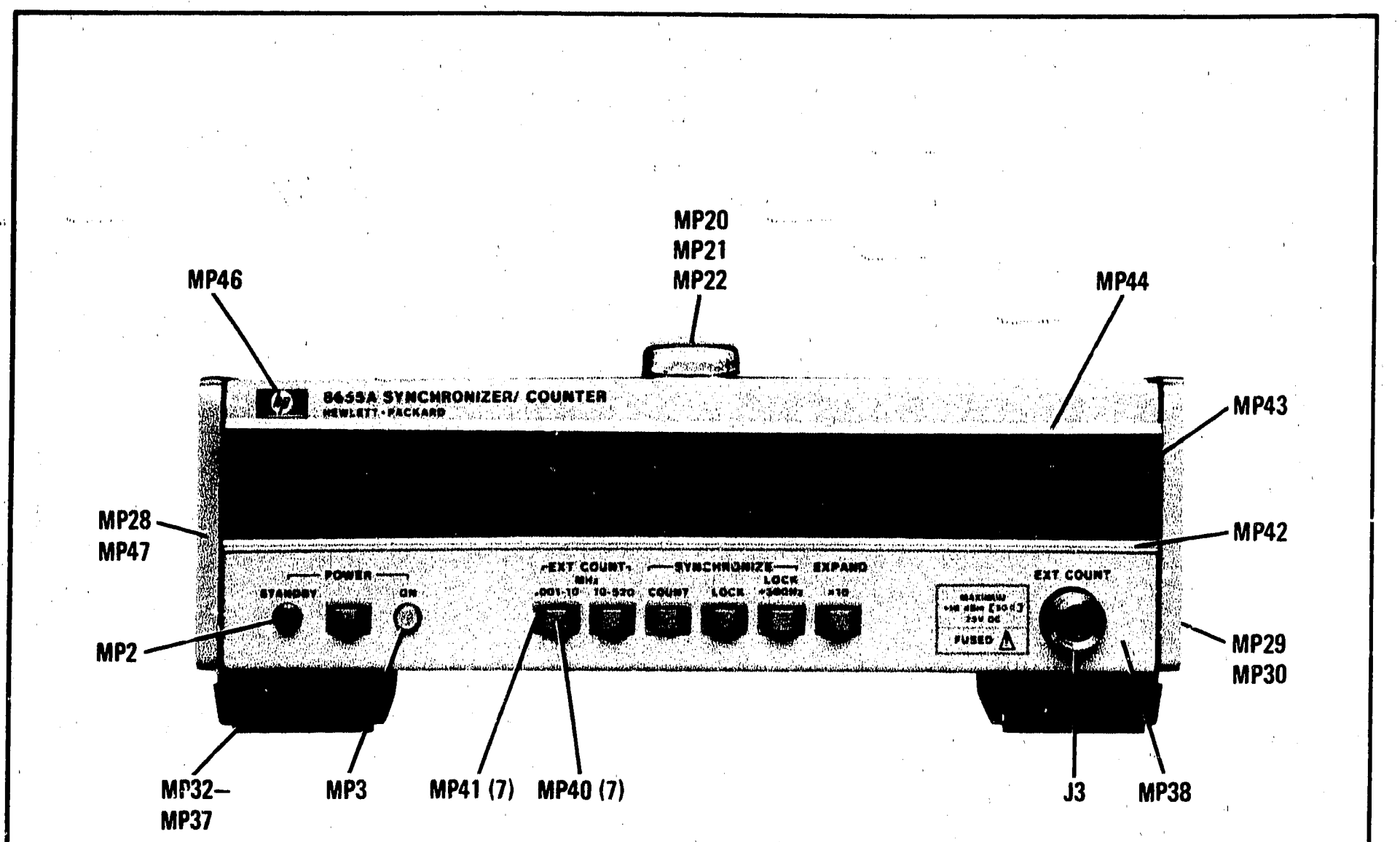
See introduction to this section for ordering information

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			MISCELLANEOUS PARTS		
	0360-0002	1	TERMINAL-LUG-SLDR 2 SCR .09/.065 ID HOLE	77147	4029
	0360-0268	4	TERMINAL-LUG-SLDR 6 SCR .143/.093 ID	83330	1414-6
	0520-0021	2	SCREW-MACH 2-56 .188-IN-LG FIL-HD-SLT	95987	N-256-3/16
	0590-0052	4	NUT-SHMET-J 6-32-THD .5-WD STL	78553	C-8020-632-248
	0590-0505	1	NUT, KNURLED 5/8-24 UNEF-2B THREAD	73743	TD-801
	0610-0001	2	NUT-HEX-DBL-CHAM 2-56-THD .062-THK	28480	0610-0001
	0890-0057	5	TUBING-HS .33-D/.225-RCVD .02-WALL PVC	76381	3024-060 FR-1
	1400-0024	2	CLAMP-CA .5-IN-WD NYL	28520	3324
	2190-0006	1	WASHER-LK HLCL NO.-6 .141-IN-ID	28480	2190-0005
	2190-0045	5	WASHER-LK HLCL NO.-2 .088-IN-ID	76854	1501-009
	2190-0067	2	WASHER-LK INTL T NO.-1/4 .256-IN-ID	78189	1914-05
	2200-0103	21	SCREW-MACH 4-40 .25-IN-LG PAN-HD-POZI	28480	2200-0103
	2200-0105	7	SCREW-MACH 4-40 .312-IN-LG PAN-HD-POZI	28480	2200-0105
	2200-0143	1	SCREW-MACH 4-40 .375-IN-LG PAN-HD-POZI	28480	2200-0143
	2200-0164	8	SCREW-MACH 4-40 .188-IN-LG 82 DEG	28480	2200-0164
	2200-0165	6	SCREW-MACH 4-40 .25-IN-LG 82 DEG	28480	2200-0165
	2260-0009	1	NUT-HEX-W/LKWR 4-40-THD .094-THK .25-A/F	28480	2260-0009
	2360-0115	3	SCREW-MACH 6-32 .312-IN-LG PAN-HD-POZI	28480	2360-0115
	2360-0123	6	SCREW-MACH 6-32 .625-IN-LG PAN-HD-POZI	28480	2360-0123
	2360-0181	4	SCREW-MACH 6-32 .25-IN-LG 82 DEG	28480	2360-0181
	2360-0182	20	SCREW-MACH 6-32 .312-IN-LG 82 DEG	28480	2360-0182
	2360-0190	14	SCREW-MACH 6-32 .188-IN-LG 100 DEG	28480	2360-0190
	2360-0203	2	SCREW-MACH 6-32 .625-IN-LG PAN-HD-POZI	28480	2360-0203
	2360-0229	2	SCREW-MACH 6-32 .562-IN-LG PAN-HD-POZI	28480	2360-0229
	2580-0003	4	NUT-HEX-W/LKWR 8-32-THD .125-THK	28480	2580-0003
	2680-0128	8	SCREW-MACH 10-32 .25-IN-LG PAN-HD-POZI	28480	2680-0128
	2950-0052	2	NUT-HEX-DBL-CHAM 1/4-40-THD .062-THK	28480	2950-0052
	3030-0133	1	SCREW-SKT HD CAP 6-32 .25-IN-LG SST-300	28480	3030-0133
	3030-0143	1	SCREW-SET 6-32 .5-IN-LG SMALL CUP-PT ALY	28480	3030-0143
	3050-0105	1	WASHER-FL MTLC NO.-4 .125-IN-ID	28480	3050-0105
	3050-0227	2	WASHER-FL MTLC NO.-6 .149-IN-ID	80120	AN960C-6

Table 6-2. Replaceable Parts

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
			MECHANICAL PARTS		
MP1	1250-0838	1	CONNECTOR, RF ADAPTER,TEE(OPT 001 ONLY)	2K497	700072
MP2	1450-0153	2	LIGHT-IND LAMPHOLDER	08717	102S-R BODY
	1450-0493	1	LITE IND,LENS CAP, BLUE, STANDBY (SEE SECTION III)	08717	102-B-STD LENS
MP3	1450-0153		LIGHT-IND LAMPHOLDER	08717	102S-R BODY
	1450-0157	1	LENS CAP, WHITE,ON(SEE SECTION III)	08717	102-W-STD LENS
MP4	08655-60021	1	8655/54 COMB KIT,INCLUDES FOLLOWING ITEM (SEE SECTIONS I AND II)	28480	08655-60021
	2360-0119	8	SCREW-MACH 6-32 .438-IN-LG PAN-HD-POZI	28480	2360-0119
	8120-1839	1	CABLE-COAX 50 OHM .216-OD 19AWG	28480	8120-1839
	08655-20029	2	RAIL, COMBINING	28480	08655-20029
	08655-20032	1	CABLE ASSEMBLY, INTERCONNECT	28480	08655-20032
MP5	08655-00016	1	PLATE, REAR PANEL (OPTION 001 ONLY)	28480	08655-00016
MP6	7120-3528	1	LABEL(WARNING, FIRE HAZARD)	28480	7120-3528
MP7	7120-4295	4	LABEL(WARNING, VOLTAGE HAZARD)	28480	7120-4295
MP8	7120-4627	1	LABEL INFORMATION(CAUTION)	28480	7120-4627
MP9	7120-5043	1	LABEL, INFORMATION(FUSE)	28480	7120-5043
MP10	08655-20015	1	HOUSING, BLOWER	28480	08655-20015
MP11	08655-00003	1	SUPPORT, BLOWER	28480	08655-00003
MP12	3160-0280	1	BLOWER WHEEL .666-THK 1.5-OD .125-ID	28480	3160-0280
MP13	08655-20031	1	BUSHING, BRASS(BLOWER WHEEL)	28480	08655-20031
MP14	08655-00017	1	PLATE, SAFETY (POWER MODULE)	28480	08655-00017
MP15	08655-00002	1	DECK, COUNTER	28480	08655-00002
MP16	08655-00004	1	SUPPORT, OSCILLATOR	28480	08655-00004
MP17	08655-00008	1	SUPPORT, FILTER BOARD	28480	08655-00008
MP18	08655-00014	1	INSULATOR, HEAT SINK	28480	08655-00014
MP19	08654-00037	1	COVER, TOP	28480	08654-00037
MP20	1440-0076	1	HANDLE-SPCL 7.75-L	12136	1775-354 COLOR Y31061
MP21	1440-0077	2	HANDLE-CRPNT	12136	346
MP22	1440-0077		HANDLE-CRPNT	12136	346
MP23	08655-00005	1	PANEL, REAR	28480	08655-00005
MP24	08655-20011	1	HEAT SINK	28480	08655-20011
MP25	2530-0008	4	SCREW-MACH 8-32 2.5-IN-LG 82 DEG	28480	2530-0008
MP26	7120-2359	1	SERIAL PLATE .625-IN-WD 1.5-IN-LG AL	28480	7120-2359
MP27	1250-0822	1	CAP-COAX TO FIT F-N NON-SHTG 1.75 IN	24931	25PC100-1
MP28	08655-20016	2	FRAME ASSEMBLY, ALTERED	28480	08655-20016
MP29	08655-20016		FRAME ASSEMBLY, ALTERED	28480	08655-20016
MP30	08655-00009	1	COVER-SIDE, PERFORATED (COUNTER AIR EXHAUST)	28480	08655-00009
MP31	08654-00024	1	COVER, BOTTOM	28480	08654-00024
MP32	5040-7201	4	FOOT	28480	5040-7201
MP33	5040-7201		FOOT	28480	5040-7201
MP34	5040-7201		FOOT	28480	5040-7201
MP35	5040-7201		FOOT	28480	5040-7201
MP36	1460-1345	2	TILT STAND	28480	1460-1345
MP37	1460-1345		TILT STAND	28480	1460-1345
MP38	08655-00001	1	PANEL, FRONT	28480	08655-00001
MP39	1460-1453	2	SPRING EXTN(INSIDE FRONT PANEL)	28480	1460-1453
MP40	0370-2486	7	PUSHBUTTON(SOLID GRAY)	28480	0370-2486
MP41	0370-0914	7	BEZEL:PUSHBUTTON KNOB, JADE GREY	28480	0370-0914
MP42	08655-20022	1	TRIM, BOTTOM	28480	08655-20022
MP43	08655-20020	1	WINDOW	28480	08655-20020
MP44	08655-20021	1	TRIM, TOP	28480	08655-20021
MP45	08655-20005	2	MOUNT, PANEL(INSIDE FRONT PANEL)	28480	08655-20005
MP46	7120-1254	1	PLATE, IDENTIFICATION(HP LOGO)	28480	7120-1254
MP47	08655-00012	1	COVER, SIDE (FAN INTAKE)	28480	08655-00012
MP48	1250-0964	2	NUT, RF CONNECTOR(INCLUDED IN W1 AND W4)	24931	N126-2
MP49	2420-0001	8	NUT-HEX-W/LKWR 6-32-THD .109-THK	28480	2420-0001



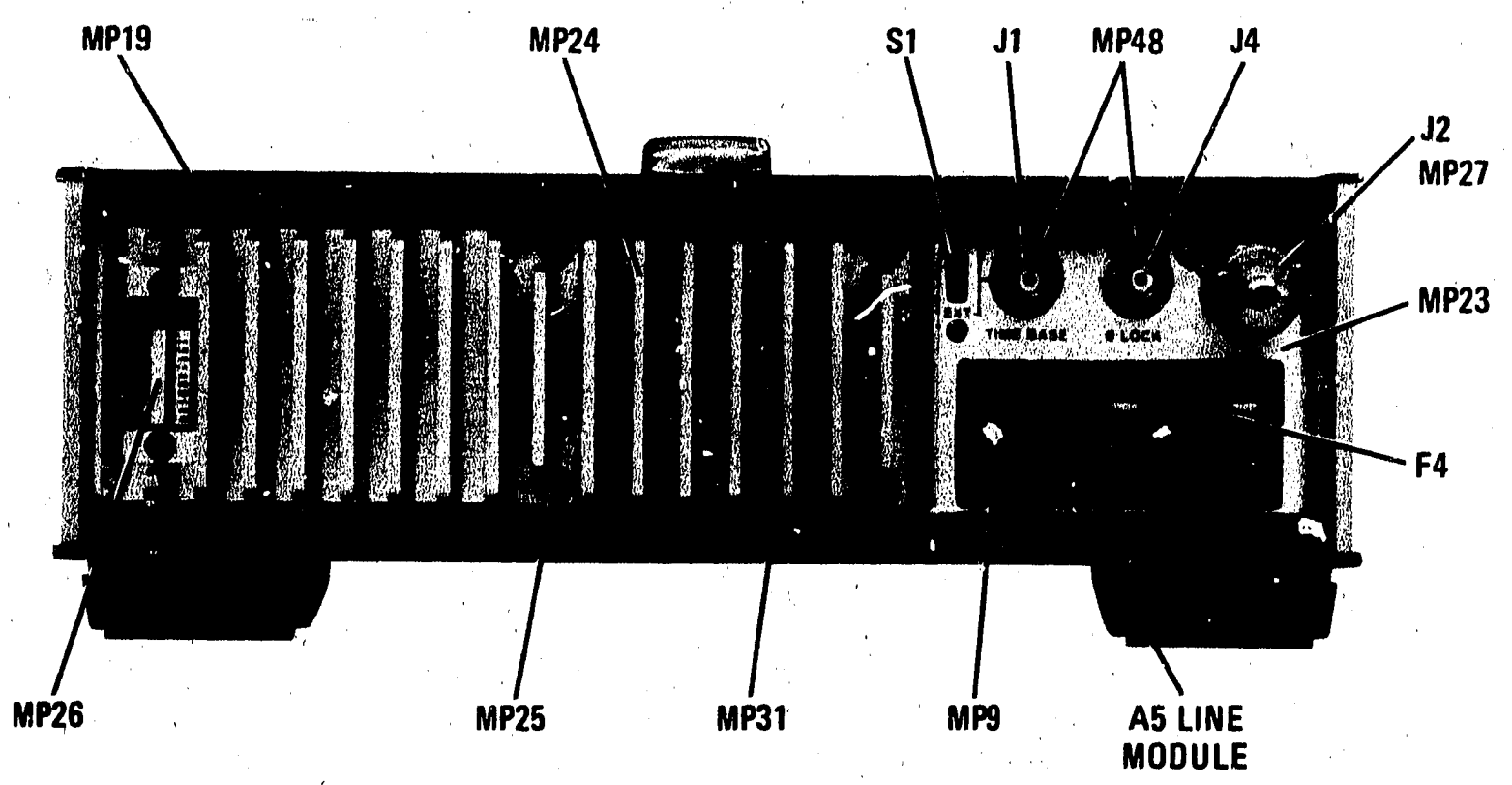
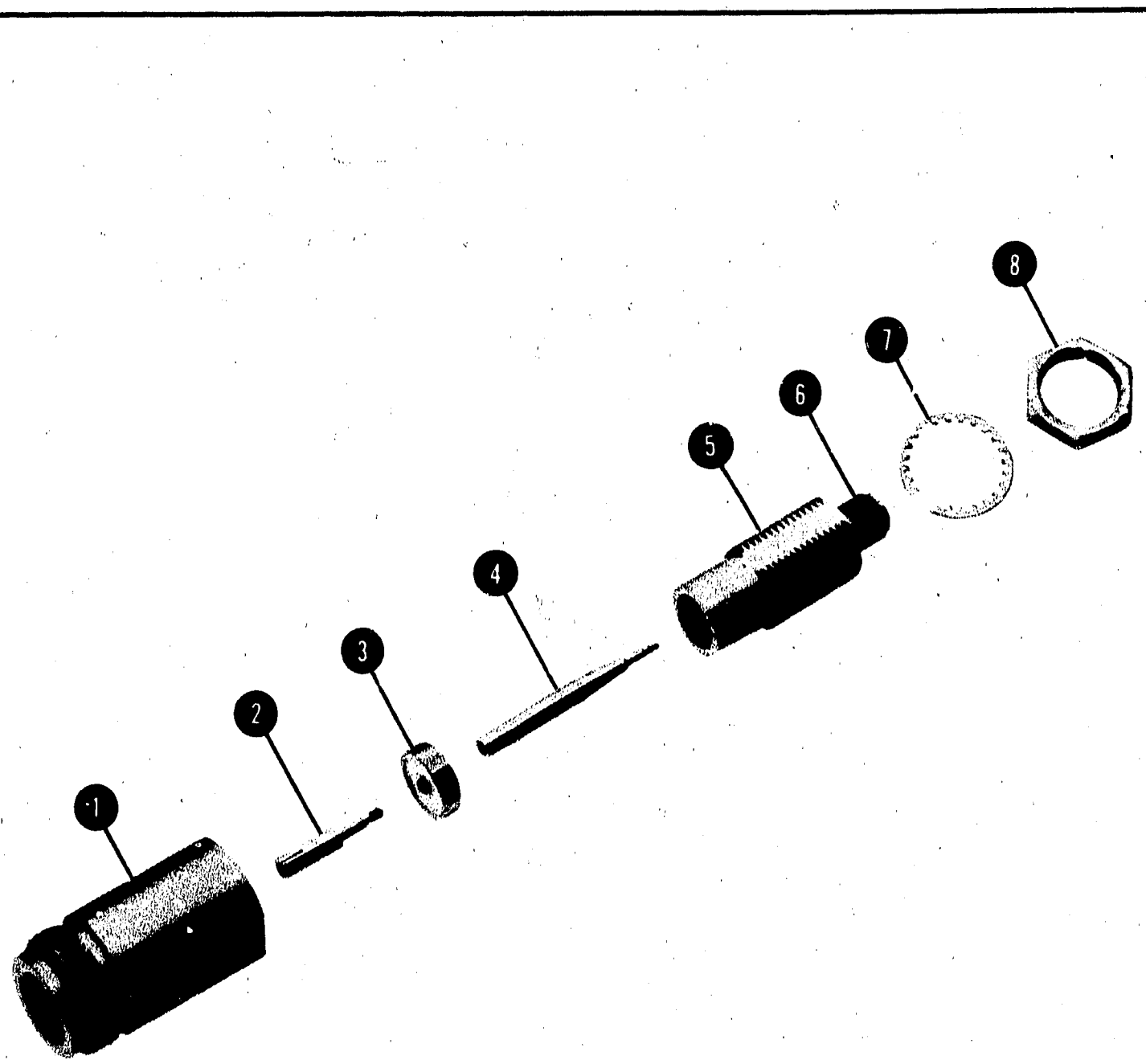


Figure 6-1. Locations of External Mechanical Parts



Item	HP Part Number	Qty	Description	Mfr. Code	Mfr. Part Number
J3	08655-60020	1	CONNECTOR ASSEMBLY, EXT COUNT, FRONT (Items 7 and 8 must be ordered separately)	28480	08655-60020
1	1250-0914	1	CONNECTOR—RF APC—N FEM UNMTD	90949	131-150
2	1250-0915	1	CONTACT, RF CONNECTOR, FEMALE CENTER	71785	131-149
3	5040-0306	1	INSULATOR	28480	5040-0306
4	08555-20093	1	CONTACT, JACK	28480	08555-20093
5	08555-20094	1	BODY, BULKHEAD	28480	08555-20094
6	08761-2027	1	INSULATOR	28480	08761-2027
7	2190-0104	1	WASHER-LK INTL T NO.-7/16 .439-IN-ID	78189	1922-04
8	2950-0132	1	NUT-HEX-DBL-CHAM 7/16-28-THD .094-THK	73734	76500NP

Figure 6-2. J3 Type N Connector

Table 6-3. Code List of Manufacturers

Mfr Code	Manufacturer Name	Address	Zip Code
00000	U.S.A. COMMON	ANY SUPPLIER OF THE US	
00501	ILLUMINATED PRODUCTS INC	ANAHEIM CA	92803
00779	AMP INC	HARRISBURG PA	17105
00853	SANGAMO ELEC CO S CAROLINA DIV	PICKENS SC	29671
01121	ALLEN-BRADLEY CO	MILWAUKEE WI	53212
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS TX	75231
02735	RCA CORP SOLID STATE DIV	SOMMERVILLE NJ	08876
03888	KDI PYROFILM CORP	WHIPPANY NJ	07981
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHOENIX AZ	85008
06383	PANDUIT CORP	TINLEY PARK IL	60477
06776	ROBINSON NUGENT INC	NEW ALBANY IN	47150
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW CA	94040
08717	SLOAN CO THE	SUN VALLEY CA	91352
12136	PHILADELPHIA HANDLE CO INC	CAMDEN NJ	08103
12697	CLAROSTAT MFG CO INC	DOVER NH	03820
16299	CORNING GL WK ELEC CMPNT DIV	RALEIGH NC	27604
19701	MEPCO/ELECTRA CORP	MINERAL WELLS TX	76067
2K497	CABLEWAVE SYSTEMS INC	NORTH HAVEN CT	06473
23050	PRODUCT COMPONENT CORP	MT VERNON NY	10553
24226	GOWANDA ELECTRONICS CORP	GOWANDA NY	14070
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD PA	16701
24931	SPECIALTY CONNECTOR CO INC	INDIANAPOLIS IN	46227
26365	GRIES REPRODUCER CORP	NEW ROCHELLE NY	10802
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA CA	95051
27264	MOLEX PRODUCTS CO	DOWNERS GROVE IL	60515
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO CA	94304
28520	HEYMAN MFG CO	KENILWORTH NJ	07033
30983	MEPCO/ELECTRA CORP	SAN DIEGO CA	92121
32997	BOURNS INC TRIMPOT PROD DIV	RIVERSIDE CA	92507
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS MA	01247
71400	BUSSMAN MFG DIV OF MCGRAW-EDISON CO	ST LOUIS MO	63017
71744	CHICAGO MINIATURE LAMP WORKS	CHICAGO IL	60640
71785	TRW ELEK COMPONENTS CINCH DIV	ELK GROVE VILLAGE IL	60007
73734	FEDERAL SCREW PRODUCTS CO	CHICAGO IL	60618
73743	FISCHER SPECIAL MFG CO	CINCINNATI OH	45206
75042	TRW INC PHILADELPHIA DIV	PHILADELPHIA PA	19108
75915	LITTELFUSE INC	DES PLAINES IL	60016
76381	3M COMPANY	ST PAUL MN	55101
76530	TRW ELEK CMPNT CINCH-MONADNOCK DIV	CITY OF INDUSTRY CA	91747
76854	OAK IND INC SW DIV	CRYSTAL LAKE IL	60014
77147	PATTON-MACGUYER CO DIV OF AVID CORP	PROVIDENCE RI	02905
78189	ILLINOIS TOOL WORKS INC SHAKEPROOF	ELGIN IL	60126
78553	TINNERMAN PRODUCTS INC	CLEVELAND OH	44129
79727	C-M INDUSTRIES	WARMINSTER PA	18974
80120	SCHNITZER ALLOY PRODUCTS CO	ELIZABETH NJ	07206
83330	SMITH HERMAN H INC	BROOKLYN NY	11207
86928	SEASTROM MFG CO	GLENDALE CA	91201
9D949	AMPHENOL SALES DIV OF BUNKER-RAMO	HAZELWOOD MO	63042
95987	WECKESSER CO INC	CHICAGO IL	60641
98291	SEALECTRO CORP	MAMARONECK NY	10544

BACK DATING MANUAL CHANGES

SECTION VII
MANUAL CHANGES

7-1. INTRODUCTION

7-2. This section normally contains information for adapting this manual to instruments for which the content does not apply directly. Since this manual does apply directly to instruments having serial numbers listed on the title page, no change information is given here. Refer to INSTRUMENTS COVERED BY MANUAL in Section I for additional important information about serial number coverage.

SERVICE INFO

SECTION VIII
SERVICE

WARNINGS

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

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

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

Any interruption of the protective (grounding) conductor (inside or outside the instrument) or disconnecting the protective earth terminal is likely to make this instrument dangerous. Intentional interruption is prohibited.

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

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

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

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

The front panel POWER switch does not have an off position. Whenever the power cord is connected between the instrument and a power source, hazardous voltage is present inside the instrument.

8-1. INTRODUCTION

8-2. This section contains instructions for troubleshooting and repairing the Synchronizer/Counter. It includes principles of operation, troubleshooting information, component location photographs, schematics, an illustrated parts breakdown, instrument internal views, and disassembly procedures. The rest of the section has general service information that should help you service and repair the instrument.

8-3. PRINCIPLES OF OPERATION

8-4. Principles of operation appear on the foldout pages opposite the block diagram and schematics. Service Sheet 1 is a block diagram that briefly describes overall instrument operation. It is keyed, by the numbers in the lower, right-hand corners of the blocks, to the schematics on the service sheets that follow. These service sheets provide a stage-by-stage description of the circuits on the schematics. The descriptions are keyed to stage names that appear in brackets on the schematics.

NOTE

Figure 8-10, Schematic Diagram Notes, explains most symbols that appear on the schematics.

8-5. TROUBLESHOOTING

8-6. Overall Troubleshooting. One method of isolating a problem to a particular assembly is to compare results of various related tests listed in Table 5-2, Related Repairs, Performance Tests and Adjustment Procedures. A second, and preferred, method is to use the overall troubleshooting steps in paragraph 8-45. Each step in this test

TROUBLESHOOTING (cont'd)
is keyed to additional troubleshooting information located on other service sheets opposite the schematics.

8-7. Circuit-Level Troubleshooting. After a problem has been isolated to an assembly (and corresponding service sheet), the text and table on the service sheet present detailed troubleshooting information for the circuit.

8-8. RECOMMENDED TEST EQUIPMENT

8-9. A list of test equipment required for troubleshooting is found in each troubleshooting procedure. Descriptions and critical specifications for the listed equipment are located in the table of Recommended Test Equipment in Section I. Substitute equipment can be used if it meets the minimum critical specifications.

8-10. SERVICE AIDS

8-11. Posidriv Screwdrivers. Many screws in the instrument appear to be Phillips, but are not. To avoid damage to the screw slots, Posidriv screwdrivers should be used.

8-12. Service Kit. The following parts can be ordered for use in a service kit. However, before ordering, check to ensure they are not already on hand; most are common to service kits for other Hewlett-Packard instruments.

Test Cable (SMC to BNC) . . . . . HP 11592-60001
Extender Board (30 pin) . . . . . HP 5060-0049
Extender Board (12 pin) . . . . . HP 5060-0257

8-13. Spare Fuses. A spare fuse for power supply regulators and a spare fuse for the counter's RF input are mounted on the A4 Power Supply/Control Board Assembly.

8-14. Part Location Aids. The locations of most external chassis-mounted parts are shown in photographs in Section 6. Most internal parts are shown on Service Sheet B. The locations of individual components mounted on printed circuit boards or other assemblies are shown on the appropriate schematic diagram page or on the page opposite it. The part reference designator is the assembly designator plus the part designator (for example, A6R9 is R9 on the A6 assembly). For specific component description and ordering information refer to the parts list in Section 6.

8-15. Servicing Aids on Printed Circuit Boards. The servicing aids include test points, transistor and integrated circuit designations, adjustment callouts and assembly stock numbers.

8-16. FACTORY SELECTED COMPONENTS

8-17. Some component values are selected at the time of final checkout at the factory (see Table 5-1). Usually these values are not extremely critical; they are selected to provide optimum compatibility with associated components. These components are identified on individual schematics by an asterisk (*). The recommended procedure for replacing a factory-selected part is as follows:

a. Try the original value, then perform the calibration test specified for the circuit in the performance and adjustment sections of this manual.

b. If calibration cannot be accomplished, try the typical value shown in the parts list and repeat the test.

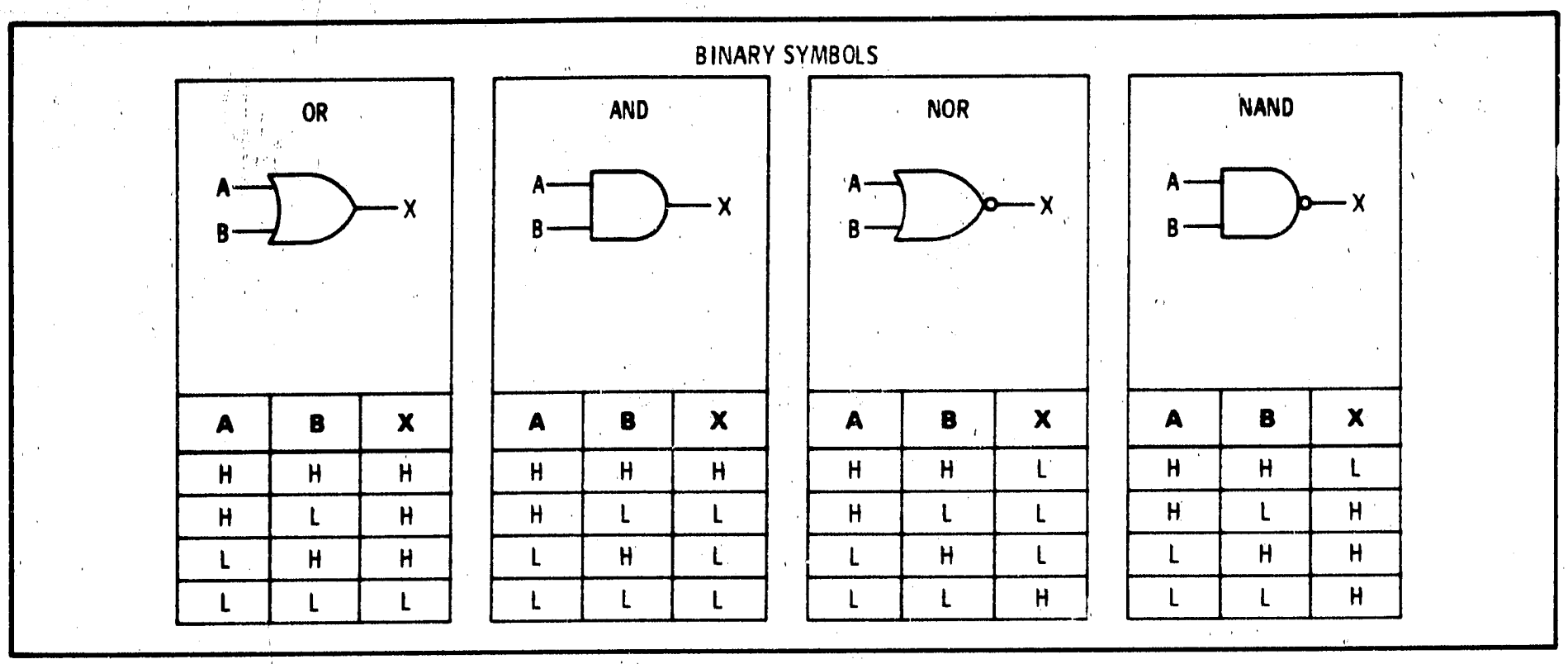
c. If the test results are still not satisfactory, substitute various values within the tolerances specified in Table 5-1 until the desired result is obtained.

8-18. BASIC CIRCUIT THEORY

8-19. Binary Circuits and Symbols

8-20. Introduction. The binary circuits and symbols used in this manual are shown in Figure 8-1 Binary Symbols and 8-10 Schematic Diagram Notes. This instrument uses three different families of logic circuits: TTL, ECL, and EECL. Most of the logic devices used in this instrument are TTL; there are notes on the Service Sheets that indicate what families the non-TTL devices belong to. Figure 8-10 shows the voltage levels that are associated with each family and the effect that an open and a ground has on each family.

8-21. In general, binary signals that are active-low are indicated with an L in parenthesis (e.g., CLOCK(L) indicates a clock signal that is active-low). Active-high signals are indicated with an H in parenthesis. A circle at an input indicates that it is active-low or triggers on a low-going edge; a circle at an output indicates inversion or that the output is active-low. Active-high inputs, inputs which trigger on a high-going edge, and active-high out-



A	B	X
H	H	H
H	L	H
L	H	H
L	L	L

A	B	X
H	H	H
H	L	L
L	H	L
L	L	L

A	B	X
H	H	L
H	L	L
L	H	L
L	L	H

A	B	X
H	H	L
H	L	H
L	H	H
L	L	H

Figure 8-1. Binary Symbols

Binary Circuits and Symbols (cont'd)

puts are shown without the circle. Complementary outputs are usually designated with a not-bar (e.g., the complement of a flip-flop's Q output is its $\overline{Q}$ output). Both Q and $\overline{Q}$ may be simultaneously high in some instances (e.g., when both SET and CLEAR are low on some D flip-flops).

NOTES

The term "binary coded decimal" (or BCD) refers to four-bit binary circuits that range from decimal 0 to 9 in 8421 code.

The term "binary", when applied to four-bit binary circuits, refers to circuits that range from decimal 0 to 15 in 8421 code.

8-22. Trigger (T) inputs are usually high-going (edge sensitive) unless there is a circle at the input (which would make them low-going). All other inputs are usually level sensitive.

8-23. Triggered Flip-Flop. There are two kinds of triggered flip-flops. The bistable triggered flip-flop (Figure 8-2) changes state each time the trigger input (T) changes to the appropriate state. This effectively divides the input by two, giving one output pulse at the Q output for every two input pulses.

8-24. The monostable triggered flip-flop's Q output goes high when triggered by the T input. However, after a set amount of time (determined either by the flip-flop's configuration or unless retriggered) the Q output automatically returns to its original state. The monostable flip-flop (or one shot) is used to stretch or shape pulses.

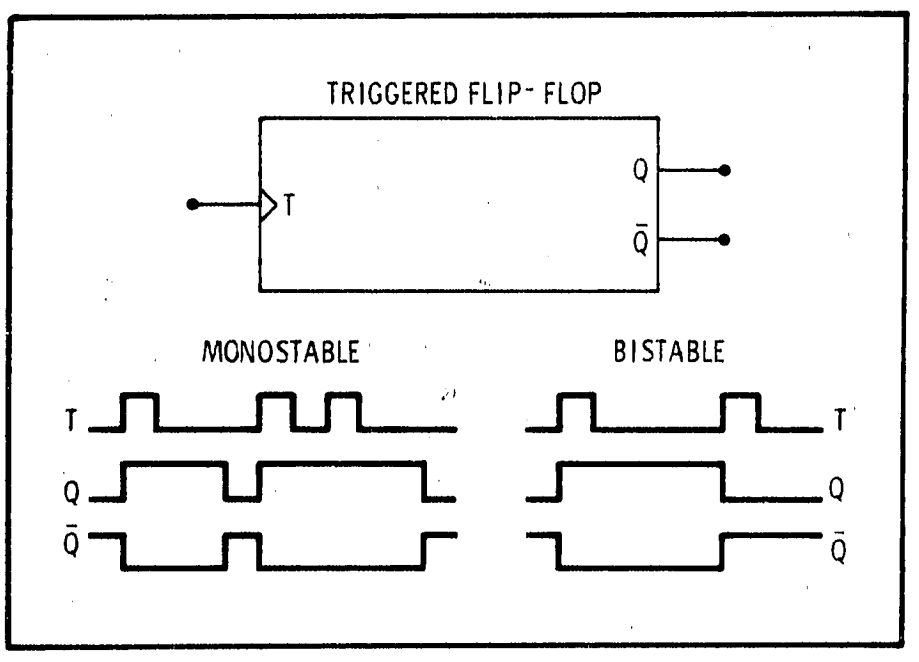


Figure 8-2. Triggered Flip-Flop

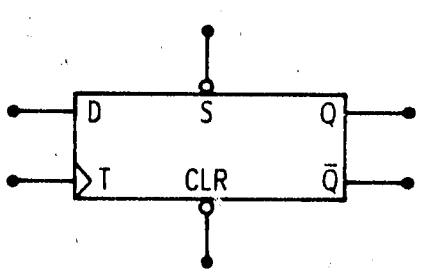
8-25. D Flip-Flop. The D-type flip-flop, shown in Figure 8-3 is used as a storage latch or buffer. The information at the data input (D) is transferred to the Q output when triggered by the T input. Once the T input has passed its threshold, the D input is locked out and the Q outputs do not change until another trigger occurs at the T input.

8-26. The set (S) and clear (CLR) inputs override all other input conditions: when set is low, the Q output is forced high; when clear is low, the Q output is forced low. Although normally the $\overline{Q}$ output is the compliment of the Q output,

Binary Circuits and Symbols (cont'd)
simultaneous low inputs at S and CLR will force both Q and $\overline{Q}$ high on some D flip-flops.

NOTE

If $\overline{Q}$ output is connected to D input, the signal at Q is T ÷ 2.



BEFORE TRIGGER	AFTER TRIGGER	
D INPUT	Q OUTPUT	$\overline{Q}$
0	0	1
1	1	0

Figure 8-3. D Flip-Flop

8-27. Binary Registers

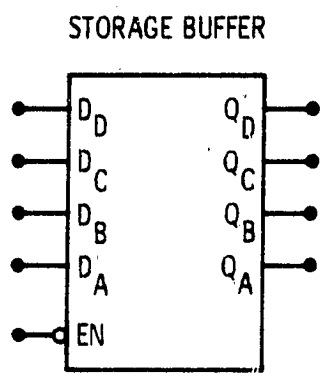
8-28. Storage Buffer. The four bit binary register shown in Figure 8-4 is used as a storage latch. Information data (D_n)* inputs is transferred to the respective Q_n* outputs when the enable (EN) input is low. When the enable goes high, the outputs are latched and are no longer affected by the data inputs.

8-29. Binary Shift Register. A five bit binary shift register is shown in Figure 8-5. Information of the data (D_n)* inputs is transferred to the respective Q_n* outputs when the load (LD) input is high. The load input is independent of the clock (T) input.

8-30. If the load input is low, a high going clock pulse shifts the output to the next adjacent output (e.g., the output of Q_B now appears as the output of Q_C). Also, the input state at the serial (SER) input appears at the Q_A output.

8-31. A low at the clear (CLR) input clears all outputs to a low independent of the clock. The clear input overrides the load input.

* n = A, B, C, or D



BEFORE ENABLE	AFTER ENABLE
INPUT D_n	OUTPUT Q_n
0	0
1	1

Figure 8-4. Storage Buffer

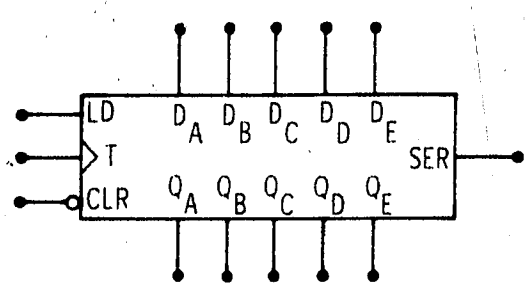
8-32. Decade Counters and Symbols

8-33. Basic Counter. The basic decade counter (or scaler or divider), shown in Figure 8-6, has ten logic states. The active-high outputs (Q_A, Q_B, Q_C, and Q_D) increment by one BCD count each time the trigger (T_A) or clock input goes from a high to a low. The count sequence is also shown in the figure. The counter may be subdivided into a divide-by-two and a divide-by-five counter. The two counters are connected in series (the Q_A output connected to the T_{BD} input) to obtain a divide-by-ten counter. The counter has two ANDed clear or reset-to-zero (R_0) inputs. When both R_0 inputs are high, the outputs clear to zero. The clear function overrides the clock. Similarly, the two ANDed set or reset-to-nine (R_9) inputs set the outputs to the nine count. If all reset-to-zero and reset-to-nine inputs are simultaneously high, the reset-to-nine overrides the reset-to-zero.

8-34. Programmable Counter. The programmable decade counter, shown in Figure 8-7, operates similarly to the basic decade counter when the load (LD) input is high. The counter shown has only a single clear (CLR) input which is active-low. When the load input is low, the information, at the data (or preset) inputs (D_A, D_B, D_C, and D_D) is transferred to the outputs at the next high going clock (T) input (synchronous loading). The outputs remain in the preset state until the load input returns

Decade Counters and Symbols (cont'd)

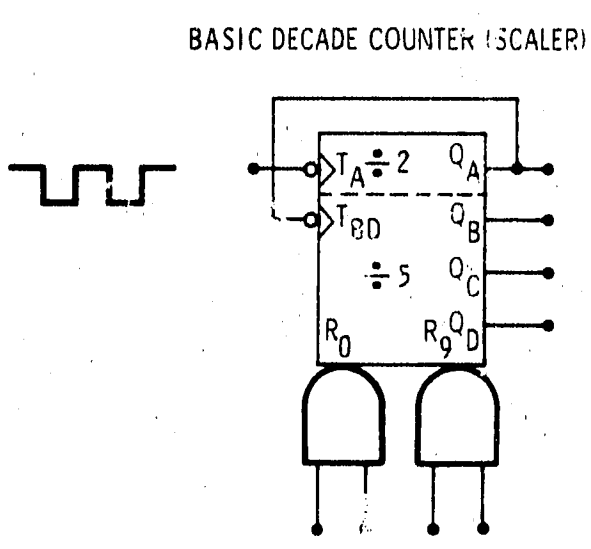
to a high and the trigger (T) or clock input again goes high — at which time the count increments by one. The counter may be preset to a count greater than nine, but in such cases the count proceeds as shown in the state diagram.



OUTPUT	OUTPUT STATE BEFORE CLOCK	OUTPUT STATE AFTER CLOCK
Q_A	A	SER *
Q_B	B	A
Q_C	C	B
Q_D	D	C
Q_E	E	D

* The state of the serial (SER) input

Figure 8-5. Binary Shift Register



COUNT	OUTPUT			
T_A	Q_D	Q_C	Q_B	Q_A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

Figure 8-6. Basic Decade Counter (Scaler)

8-35. If the counter has a count enable (CE) input, it must be held high for successive T inputs to cause the counter to increment (or count). When the counter reaches the nine count, a terminal-count or carry (in this case, a high) appears at the carry (TC) output.

NOTE

If TC output is connected to CE of another counter and a common trigger applied, both counters will count synchronously. The second counter, however, counts only when enabled by the first counter.

8-36. A low on the clear (CLR) input clears all outputs to a low independent of any other input conditions.

8-37. Programmable Up/Down Counter. The programmable up/down counter, shown in Figure 8-8 operates similarly to the programmable counter (which could be called a programmable up counter). The up/down counter has two trigger or clock inputs, count up (CU) and count down (CD). A low-to-high transition of either count input (while the other count input is held high) increments the count by one. If both CU and CD are high, the count does not increment.

8-38. The counter's outputs (Q_A, Q_B, Q_C, and Q_D) can be set to any count from zero to fifteen by entering the count at the data inputs (D_A, D_B, D_C, and D_D) while the load input (LD) is held low. Then the count can be incremented up or down by activating either the CU or CD input.

8-39. The borrow (BRW) output is low whenever the Q outputs are at BCD zero (0000). The carry (CRY) output is low whenever the Q outputs are at BCD nine (1001). The master clear input (CLR) overrides all other input conditions and forces the Q outputs to BCD zero.

8-40. Linear Integrated Circuits

8-41. Operational Amplifier. Figure 8-9 shows a typical operational amplifier. Circuit A is a non-inverting buffer amplifier with a gain of 1. Circuit B is a non-inverting amplifier with gain determined by the impedance of R1 and R2. Circuit C is an inverting amplifier with gain determined by R2 and R1. Circuit D shows typical circuit connections and parameters. It is assumed that the amplifier has high gain, low output impedance, and high input impedance.

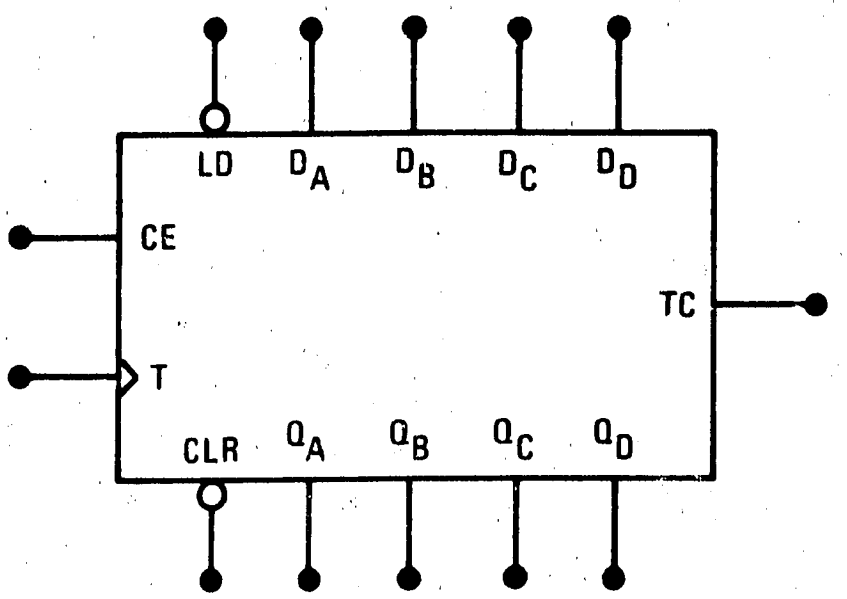
Linear Integrated Circuits (cont'd)

8-42. An operational amplifier can be characterized as an ideal voltage amplifier having low output impedance, high input impedance, and very high gain. Also the output voltage is proportional to the difference in the voltages applied to the two input terminals. In use, the amplifier output drives the input voltage difference close to zero through a negative feedback path.

8-43. When troubleshooting an operational amplifier, measure the voltages at the two inputs with no signal applied; the difference between these voltages should be less than 10 mV. A difference voltage much greater than 10 mV indicates trouble in the amplifier or its external circuitry. Usually this difference will be several volts and one of the inputs will be very close to an applied circuit operating voltage (for example, +20V, —12V).

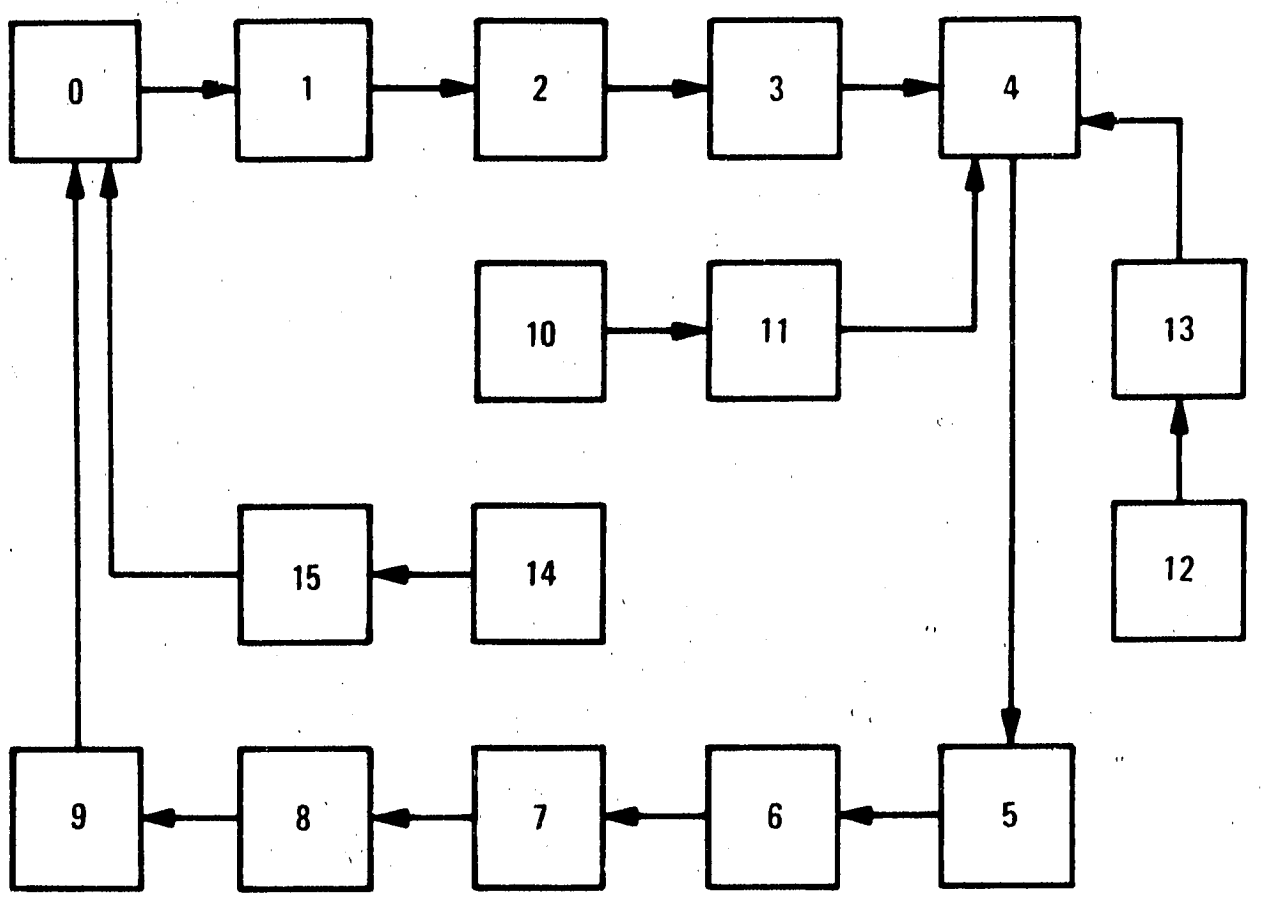
8-44. Next, check the amplifier's output voltage. It will probably also be close to one of the applied circuit potentials: ground, +20V, —12V, etc. Check to see that the output conforms to the inputs. For example, if the inverting input is positive, the output should be negative; if the non-inverting input is positive, the output should be positive. If the output conforms to the inputs, check the amplifier's external circuitry. If the amplifier's output does not conform to its inputs, it is probably defective.

PROGRAMMABLE COUNTER



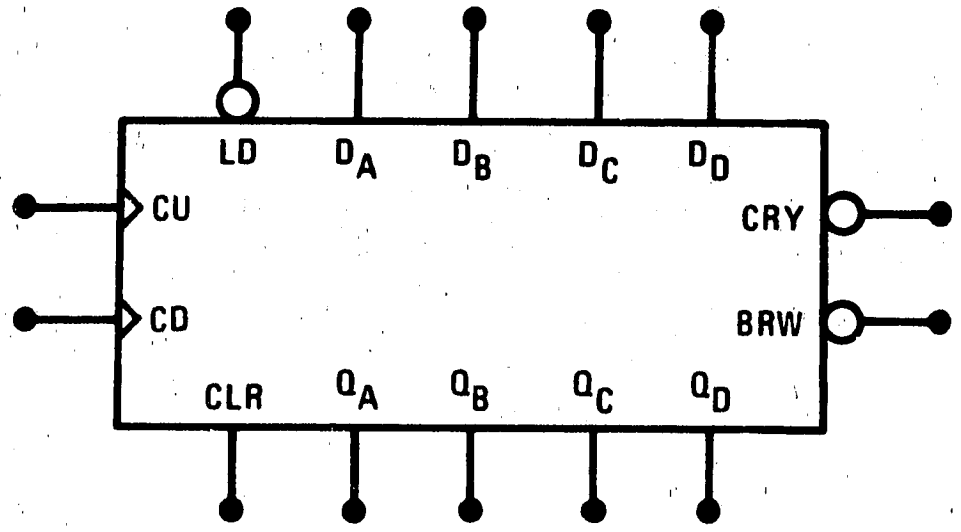
T = TRIGGER
CE = COUNT ENABLE
LD = LOAD
$D_A \ldots D_D$ = DATA INPUT
CLR = MASTER CLEAR
$Q_A \ldots Q_D$ = DATA OUTPUT
TC = TERMINAL COUNT
(9 COUNT AND CE)

BINARY STATE DIAGRAM



COUNT	Q_D	Q_C	Q_B	Q_A	COUNT	Q_D	Q_C	Q_B	Q_A
0	0	0	0	0	5	0	1	0	1
1	0	0	0	1	6	0	1	1	0
2	0	0	1	0	7	0	1	1	1
3	0	0	1	1	8	1	0	0	0
4	0	1	0	0	9	1	0	0	1

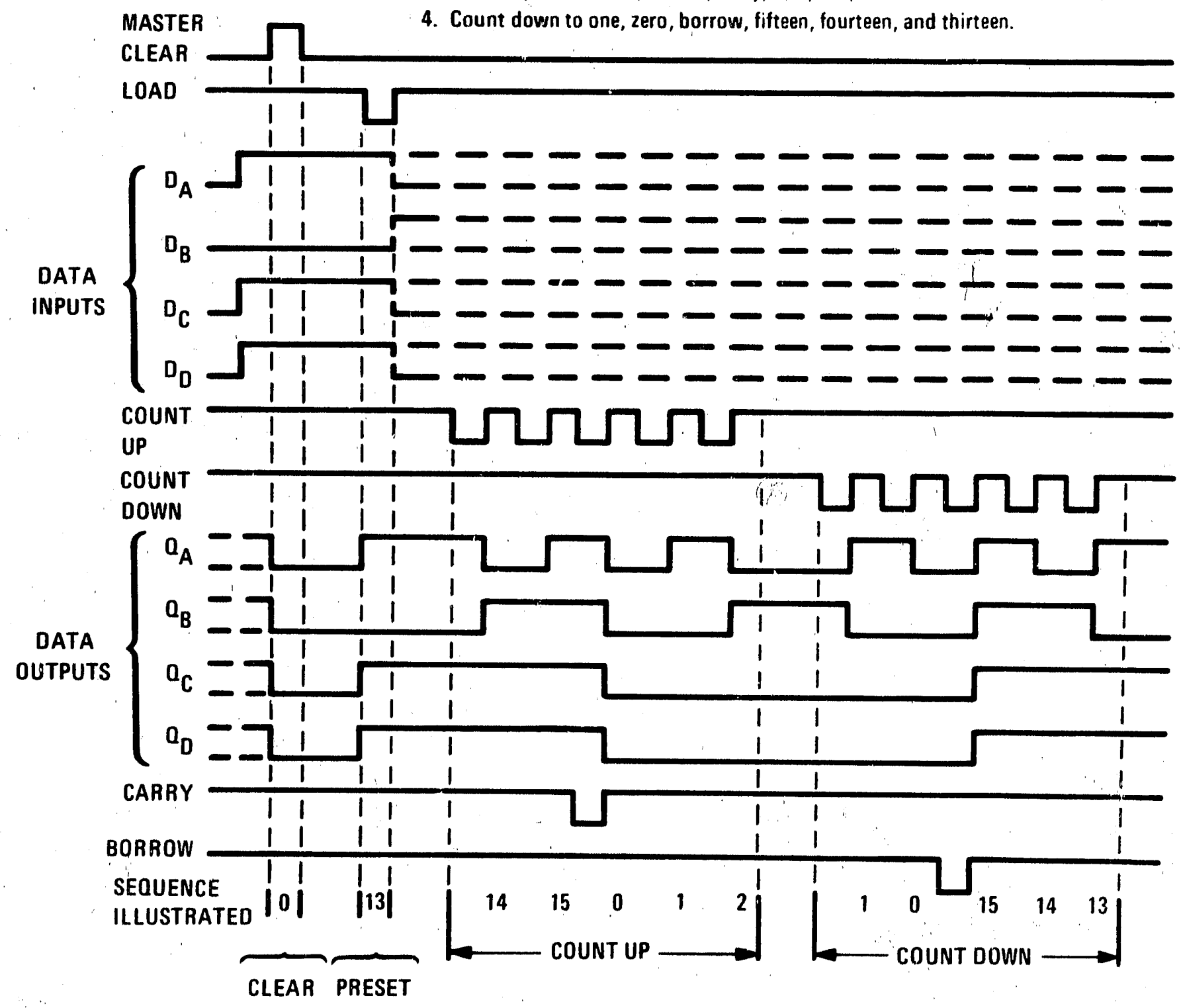
Figure 8-7. Programmable Counter



CU	=	COUNT UP
CD	=	COUNT DOWN
CLR	=	MASTER CLEAR
LD	=	LOAD
$D_A \ldots D_D$	=	DATA INPUT
$Q_A \ldots Q_D$	=	DATA OUTPUT
CRY	=	CARRY
BRW	=	BORROW

Illustrated below is the following sequence:

1. Clear outputs to zero
2. Load (preset) to BCD thirteen.
3. Count up to fourteen, fifteen, carry, zero, one, and two.
4. Count down to one, zero, borrow, fifteen, fourteen, and thirteen.

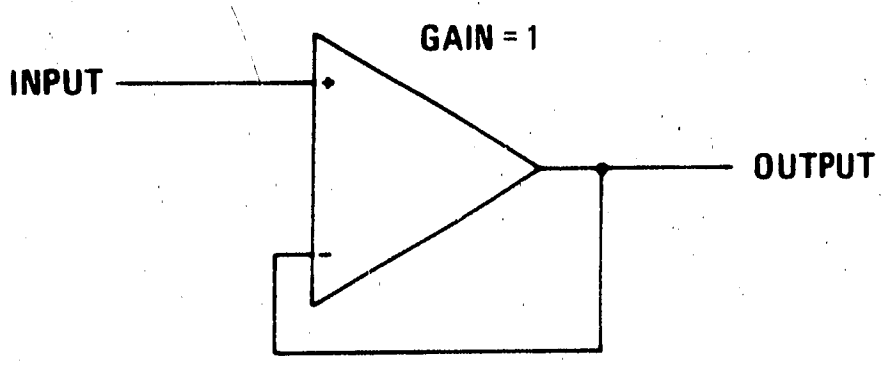


NOTES: A. Clear overrides load, data, and count inputs.
B. When counting up, count-down input is high: when counting down, count-up input is high.

Figure 8-8. Programmable Up/Down Counter

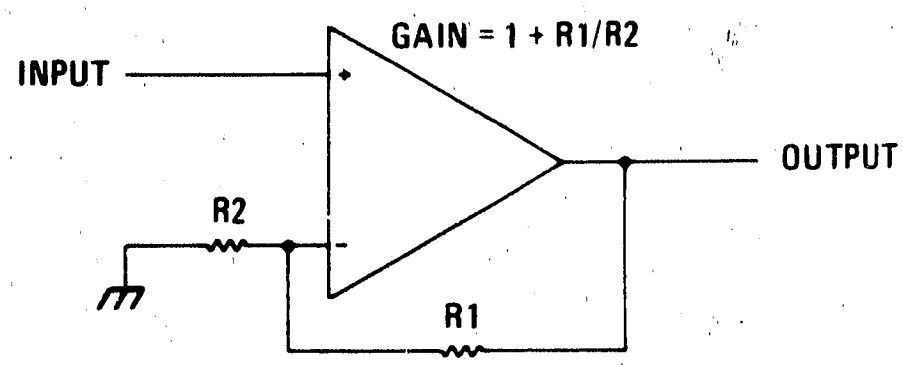
OPERATIONAL AMPLIFIER

A



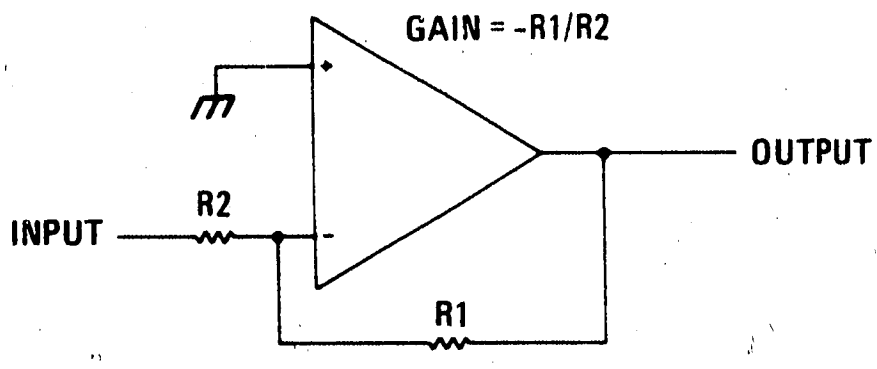
INPUT IMPEDANCE: VERY HIGH
OUTPUT IMPEDANCE: VERY LOW

B



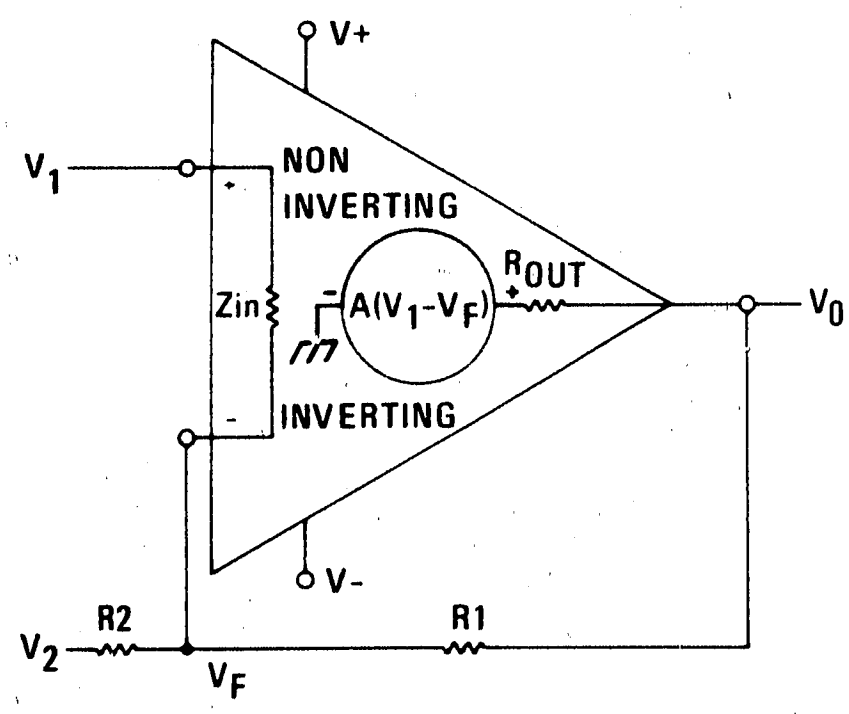
INPUT IMPEDANCE: VERY HIGH
OUTPUT IMPEDANCE: VERY LOW

C



INPUT IMPEDANCE: R2
OUTPUT IMPEDANCE: VERY LOW

D



IF "A" IS LARGE, $V_F = V_1$

(1) $$V_0 = V_1 \left(1 + \frac{R1}{R2}\right) - V_2 \left(\frac{R1}{R2}\right)$$

(2) IF $V_2 = 0$ (⏚), THEN $$V_0 = V_1 \left(1 + \frac{R1}{R2}\right)$$

(3) IF $V_1 = 0$ (⏚), THEN $$V_0 = -V_2 \left(\frac{R1}{R2}\right)$$

Figure 8-9. Operational Amplifier

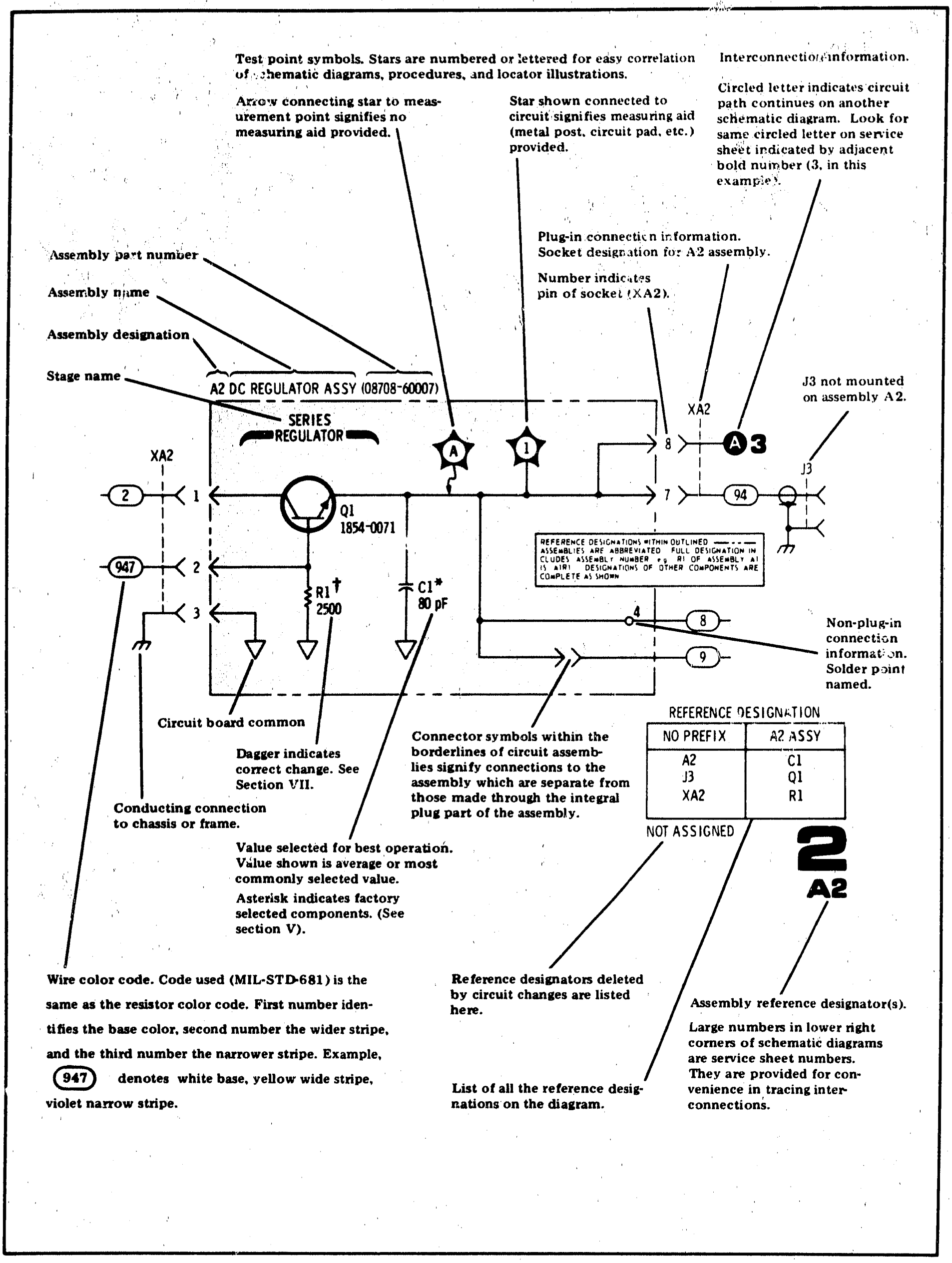


Figure 8-10. Schematic Diagram Notes (1 of 3)

SCHEMATIC DIAGRAM NOTES

Tool-aided adjustment.

Manual control.

Encloses front-panel designation.

Encloses rear-panel designation.

Circuit assembly borderline.

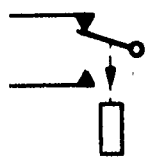
Other assembly borderline. Also used to indicate mechanical interconnection (ganging) and RF shielding.

Heavy line with arrows indicates path and direction of main signal.

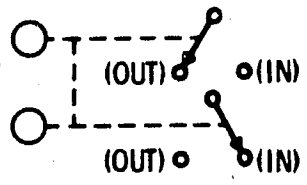
Heavy dashed line with arrows indicates count down/phase lock signal flow.

Wiper moves toward CW with clockwise rotation of control (as viewed from shaft or knob).

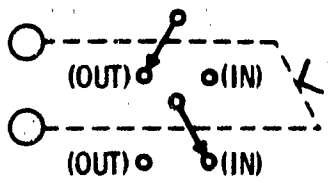
A direct conducting connection to the earth, or a conducting connection to a structure that has a similar function (e.g., the frame of an air, sea, or land vehicle).



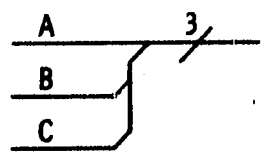
Relay contact moves in direction of arrow when energized.



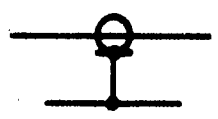
Indicates interlocked pushbutton switches. Only one switch can be in (IN) at a time.



Indicates interconnected pushbutton switches. Pushing one switch in (IN) releases the other.



Indicates multiple paths represented by only one line. Letters or names identify individual paths. Numbers indicate number of paths represented by the line.

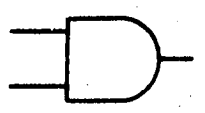


Coaxial or shielded cable.

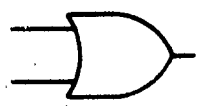
Figure 8-10. Schematic Diagram Notes (2 of 3)

LOGIC CIRCUIT NOTES

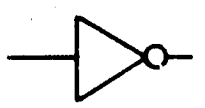
Basic Symbols



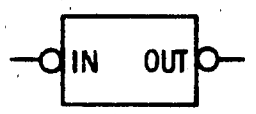
AND Gate



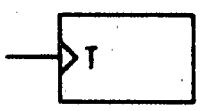
OR Gate



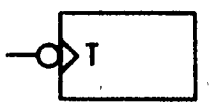
Inverter



Active-low input/output



High-going edge sensitive trigger



Low-going edge sensitive trigger

Logic Voltage Levels

LOGIC	TTL	ECL	EECL
High (H)	⩾ 2V	⩾ −0.5V	⩾ −0.1V
Low (L)	⩽ 0.8V	⩽ −1.5V	⩽ −0.6V

Circuits and functional levels (H or L) shown on schematics are TTL unless otherwise noted (e.g., ECL-H). A signal path is shown active-high (H), or low (L) according to its function at that place in the circuit only, or not indicated at all if the signal is considered active both high and low.

Input Conditioning

INPUT	TTL	ECL	EECL
Grounded	Low (L)	High (H)	High (H)
Open	High (H)	Low (L)	Low (L)

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
A1U3-9	+5.2V — 7 GND — 6

IC pin connections for supply voltage and ground are shown on schematics in boxes under NOTES.

Figure 8-10. Schematic Diagram Notes (3 of 3)

TROUBLESHOOTING

8-45. OVERALL TROUBLESHOOTING

DESCRIPTION: A fault in the instrument can usually be isolated to the functional level by following the steps in Table 8-1. The steps are simple and make maximum use of front panel controls and display indications for diagnosis. The steps in the table should be followed in order. When the first abnormality is observed, turn to the service sheet indicated and begin troubleshooting by following a similar table on that sheet. After a repair has been completed, check the instrument by again following the steps in Table 8-1 to the conclusion.

TEST EQUIPMENT:

Frequency Counter	HP 5327C
Multimeter	HP 34702A/34740A
Signal Generator	HP 8654A or HP 8654B (preferred)

PROCEDURE:

1. Remove front panel (see procedure on Service Sheet B).

2. Set controls as follows (see Figure 8-11):

POWER	STANDBY (Out)
EXT COUNT: .001-10 MHz	In
LOCK	Out
LOCK +500 Hz	Out
EXPAND x10	Out
TIME BASE (rear panel except Option 001)	INT

3. Follow the steps in Table 8-1 in sequence.

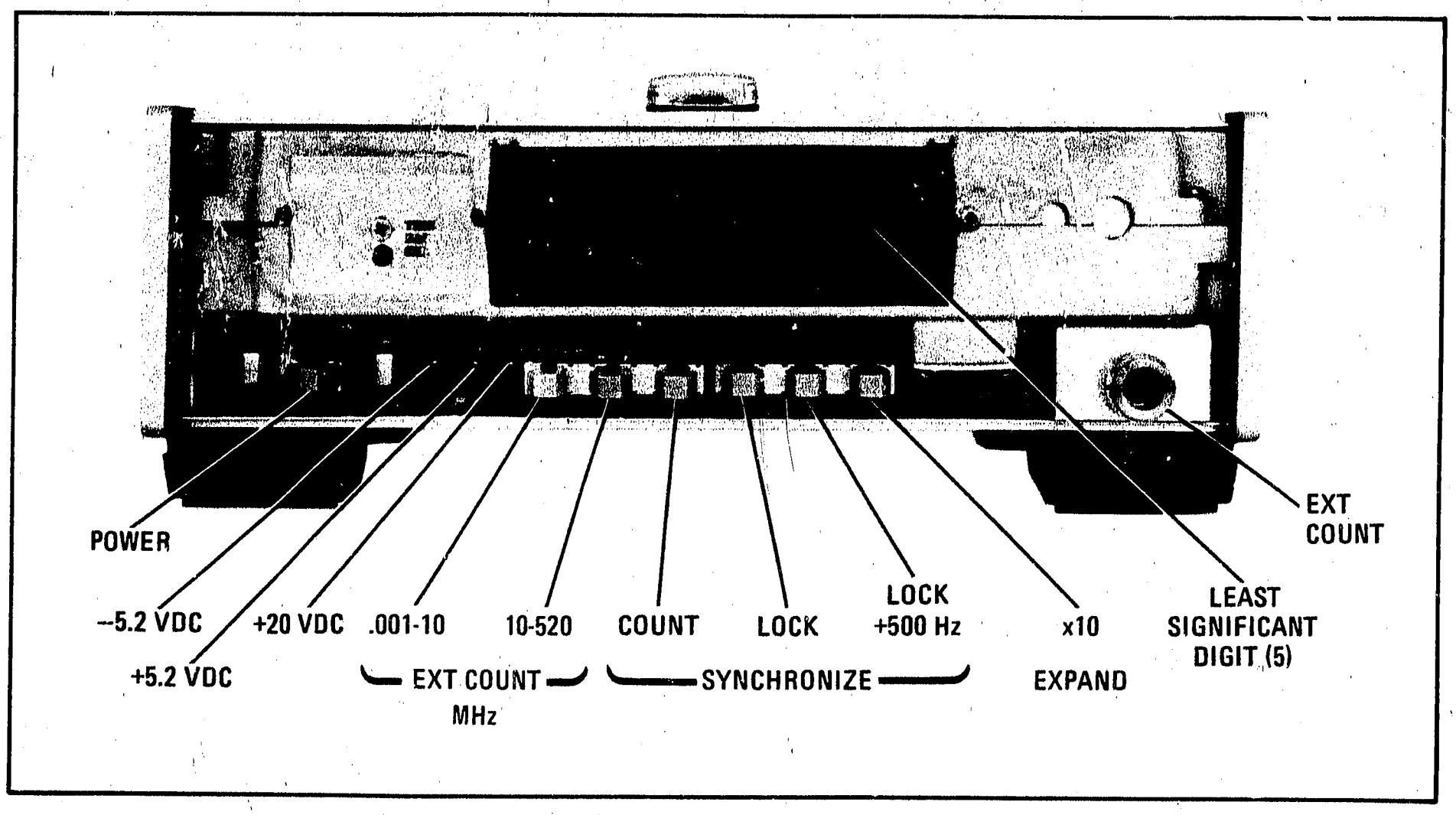


Figure 8-11. Front Panel Controls With Panel Removed

Table 8-1. Overall Troubleshooting (1 of 3)

<table>
<tr><th>Step</th><th>Instructions</th><th>Normal Indication</th><th>If Indication Abnormal</th></tr>
<tr><td>1</td><td>Install line cord.</td><td>+20V LED indicator (A4DS1) on
+5.2V and −5.2V indicators (A4DS2 and DS3) off</td><td>1) Check line fuse.
2) See Service Sheet 6, Power Supplies.</td></tr>
<tr><td rowspan="5">2</td><td rowspan="5">Set POWER switch to ON (in).</td><td>+20V, +5.2V, and −5.2V indicators on</td><td>See Service Sheet 6: Power Supplies</td></tr>
<tr><td>Fan running</td><td>See Service Sheet 6: Fan Circuits.</td></tr>
<tr><td>Display constant</td><td>1) See Service Sheet 5: Error Detector.
2) See Service Sheet 5: Phase Lock Circuits.
3) See Service Sheet 4: Flash Oscillator</td></tr>
<tr><td>Least significant digit (LSD) blank</td><td>See Service Sheet 4: 500 Hz Digit</td></tr>
<tr><td>All digits lighted except LSD</td><td>If all digits are blank,
1) See Service Sheet 2: Time Base.
2) See Service Sheet 4: Flash Oscillator.

If one or more digits are blank (excluding LSD),
1) See Service Sheet 2: Time Base.
2) See Service Sheet 4: Counter-Count Up Mode.</td></tr>
<tr><td>3</td><td>Set switches as follows and note decimal point position:
<table>
<tr><th>.001-10 MHz</th><th>10-520 MHz or SYNCH-RONIZE COUNT</th><th>EXPAND x10</th></tr>
<tr><td>In</td><td>Out</td><td>Out</td></tr>
<tr><td>In</td><td>Out</td><td>In</td></tr>
<tr><td>Out</td><td>In</td><td>In</td></tr>
<tr><td>Out</td><td>In</td><td>Out</td></tr>
</table>
</td><td>
<table>
<tr><th>Display</th></tr>
<tr><td>X.X X X X X</td></tr>
<tr><td>.X X X X X X</td></tr>
<tr><td>X X.X X X X</td></tr>
<tr><td>X X X.X X X</td></tr>
</table>
</td><td>See Service Sheet 2: Decimal Point Decoder.</td></tr>
<tr><td>4</td><td>Release EXPAND x 10. Depress .001-10 MHz. Switch POWER between STANDBY and ON at least 5 times with 5 seconds between switchings.</td><td>Display is blank in STANDBY. Display is 0.00000 in ON after a short wait.</td><td>If Display is not 0.00000 and remains the same for each ON, see Service Sheet 4: Counter-Count Up Mode.

If Display is not 0.00000 and changes for each ON, see Service Sheet 2: Time Base.</td></tr>
</table>

Table 8-1. Overall Troubleshooting (2 of 3)

Step	Instructions	Normal Indication	If Indication Abnormal
5	Set POWER to ON. Depress SYNCHRONIZE COUNT. Connect TIME BASE output (rear panel) to RF IN (rear panel).	Display reads 001.000. NOTE: Option 001 TIME BASE output may require amplification in order to trigger properly in count mode.	If Display is 000.000, 1) See Service Sheet 3: Input Circuits and Dividers. 2) See Service Sheet 4: Shaping and Counter-Count Up Mode.
			If Display is constant but not 000.000, 1) See Service Sheet 2, Time Base. 2) See Service Sheet 4: Counter-Count Up-Mode.
6	Depress EXPAND x10.	Display reads 01.0000.	See Service Sheet 2: Time Base.
7	Release EXPAND x10. Depress .001-10 MHz. Connect TIME BASE output to EXT COUNT input (front panel).	Display reads 1.00000.	See Service Sheet 3: Input Circuits and Dividers.
8	Connect dc voltmeter to ϕ LOCK output (rear panel). Internal switch A4S9 must be set to 8654 (see Service Sheet 5).	Voltmeter reads 0.0 ± 0.1 Vdc.	See Service Sheet 5: Phase Lock Driver, Low-Pass Filtering and Phase Detector circuits. If voltage is only slightly off, perform Phase Lock Offset Adjustment in Section 5.
9	Depress LOCK button.	Display reads 1.00000 for longer than 10 seconds without blinking.	1) See Service Sheet 5: Lock Switching and Phase Detector circuits. 2) See Service Sheet 4: Counter-count Down Mode. 3) See Service Sheet 2: Time Base.
10	Depress SYNCHRONIZE COUNT.	Display reads 000.000 and blinks at a 2 Hz rate.	1) See Service Sheet 5: Error Detector. 2) See Service Sheet 4: Flash Oscillator
11	Release LOCK. Depress .001-10 MHz. Depress EXPAND x10.	Display reads .000000; OVERFLOW lamp is on.	See Service Sheet 4: Overflow Detector.
12	Depress 10-520 MHz. Release EXPAND x10. Depress LOCK + 500 Hz.	Display reads 001.0005 with all but decimal point and LSD(5) blinking at a 2 Hz rate. (The "1" may also be displayed as "0" on alternate flashes of the display.)	See Service Sheet 4: 500 Hz digit.
13	If compatible signal generator is available, connect it for synchronizer operation. Then depress LOCK button on Synchronizer/Counter.	Display is constant and phase lock is maintained for several minutes (depending on warm-up).	1) See Service Sheet 5: Lock Switching and Phase Detector. 2) See Service Sheet 4: Counter-Count Down Mode. 3) See Service Sheet 2: Time Base. 4) Check generator's tuning circuits.

Table 8-1. Overall Troubleshooting (3 of 3)

Step	Instructions	Normal Indication	If Indication Abnormal
14	Monitor phase lock tune line with voltmeter. Adjust signal generator for small increase and decrease in frequency (<±0.5 Vdc on phase lock tune line).	Display is constant and phase lock is maintained.	Perform Phase Lock Error voltage Adjustment in Section 5.
15	Adjust signal generator for large increase and decrease in frequency (relock when necessary).	Display reads actual frequency of generator and blinks at a 2 Hz rate (phase lock is broken).	See Service Sheet 5: Error Detector.
16	Actual operation of the LOCK +500 Hz function can be verified by comparing the displayed frequency to the actual RF frequency using an external counter.	Display agrees with external counter.	See Service Sheet 3: Pulse Swallowing Circuit.

SERVICE SHEET 1

PRINCIPLES OF OPERATION

General

The Hewlett-Packard Model 8655A Synchronizer/Counter functions as either a six-digit RF counter or as a synchronizer which is used to stabilize an external RF signal generator against frequency drift. For synchronization, the external signal generator must have an auxiliary RF output and a compatible phase lock tune input (such as an FM input).

The instrument's function is determined by the following front panel switches:

EXT COUNT

.001–10 MHz: the 1 kHz to 10 MHz signal present at the front panel EXT COUNT jack is counted

EXT COUNT

10–520 MHz: the 10 to 520 MHz signal present at the front panel EXT COUNT jack is counted.

SYNCHRONIZE

COUNT: the signal present at the rear panel jack is counted.

LOCK: when the RF signal from an external signal generator is phase locked (synchronized) to a time base reference, the RF input is selected by the count switches; normally SYNCHRONIZE COUNT switch and rear panel RF IN are used. The specified frequency range for phase lock is 10 to 520 MHz.

LOCK +500 Hz: phase locks the RF signal to a time base reference (same as LOCK function). Also tunes generator output 500 Hz above previously indicated frequency.

SERVICE SHEET 1 (Cont'd)

Both front and rear panel RF inputs are protected by a common fuse.

The following conditions will prevent or break phase lock: 1) if an overflow exists in the counter Display, 2) if the external signal generator drifts out of the hold range, 3) if the phase lock tune line is incompatible, 4) if the signal frequency is out of the specified range. When phase lock is broken, the Display blinks at a 2 Hz rate.

Pressing EXPAND x 10 increases the count mode resolution by ten. If the most significant digit overflows the Display, the OVERFLOW annunciator turns on.

Frequency accuracy is determined by the 1 MHz time base reference. Either an internal or external time base reference can be used (standard instruments only). Option 001 provides an internal high stability crystal time base reference but does not accept an external input.

Time Base Circuits

The time base serves two functions: 1) in the count mode, it gates the counter and determines the period for which the counter counts; 2) in the phase lock mode, it is the reference the RF signal is compared to in the Null Phase Detector.

The time base is derived from either a 5 MHz crystal oscillator signal (divided by five) or an external 1 MHz reference. The internal reference is available at the rear panel TIME BASE connector as a 1 MHz signal (standard instrument only). Option 001 provides a high stability 1 MHz crystal oscillator but does not accept an external input.

The 1 MHz reference signal is then divided by 64 (normally) or 100 (in the .001—10 count mode). The ÷64 compensates the time base signal for a similar ÷64 in the RF Scaler. The signal is next divided by ten (which may also be altered to a divide-by-one for easier servicing of the counter (see Service Sheet 2), then is divided by either one (normally) or ten (EXPAND x10). The final divider is either a ÷ 100 (locked) or ÷ 101 (unlocked). When unlocked, the time base is high for 100 counts of the input and low for one count. This one count gives adequate time for the counter to transfer its count to the Display and to reset to zero between count cycle. When locked, the ÷ 100 makes the time base period equal to the period of the high time when the counter was unlocked (i.e., the one-count low period is eliminated).

The Decimal Point Decoder positions the decimal properly in the Display for the selected count and expand modes.

RF Scaler

The RF Scaler is the counter front end. It conditions the RF input signal to be compatible with the Up/Down Counter. The RF signal comes from either the front or rear panel as selected by the count switches. The Amplifier/Trigger shapes the RF signal waveform for use by the logic circuits that follow.

With either EXT COUNT 10—520 MHz or SYNCHRONIZE COUNT selected, the RF signal is divided by 64 (÷ 32 followed by ÷ 2). For EXT COUNT .001-10 MHz count mode the ÷ 64 is bypassed. The signal frequency that is fed into the Up/Down Counter is less than 10 MHz.

If the LOCK +500 Hz switch is depressed, the ÷ 64 circuit is modified slightly. Once during each count-down cycle, one RF pulse from the ÷ 32 is not allowed to toggle the divide by two. This "pulse swallowing" causes the signal frequency to seem lower than the original frequency. The phase lock loop senses this condition as a frequency error and raises the generator's frequency. The Pulse Swallowing Circuit operates with the Up/Down Counter in the phase lock mode to raise the generator's output exactly 500 Hz.

Up/Down Counter and Display — Count Mode

In the count mode the Up/Down counter is configured as a six-decade up-counter. The counter operation is controlled by the time base. When the time base is high, the counter counts the input signal, incrementing one count for each input pulse. When the time base goes low, the count input is inhibited, the counter outputs are transferred to the Storage Buffers, and the latest count appears in the Display. The Storage Buffers are then latched (i.e., they are no longer influenced by the counter outputs), and the counters are cleared to zero. When the time base returns to a high, the counter counts the input pulses beginning at zero, and the count cycle repeats.

If the count exceeds 999999, a carry (CRY) pulse is generated. The Overflow Detector then turns on

SERVICE SHEET 1 (Cont'd)

the OVERFLOW annunciator to warn that a significant digit is not shown on the Display.

Up/Down Counter and Phase Lock Circuits —Phase Lock Mode

In the phase lock mode the Up/Down Counter is configured as a six-decade down counter. The counter is free running and is not controlled by the time base. When the LOCK (or LOCK +500 Hz) switch is first depressed, the counter continues to count up until the present count cycle is terminated. The count is then stored in the Storage Buffers for the Display and for the down-counter as Count Down Preset. The counter enters the phase lock mode and counts down beginning at the Count Down Preset Frequency. The counter counts to zero, then underflows (i.e., count is 999999) and a Counter Load pulse is generated. The counter is again preset to the same number and the cycle is repeated.

The time of occurrence of the underflow (the Counter Load pulse) is compared with the termination of the time base cycle in the null phase detector. The phase detector produces a voltage proportional to the phase (or time difference) between the two signals. The detector voltage, after low-pass filtering and conditioning, drives the appropriate phase lock or FM input of the external signal generator. This voltage tunes the generator to bring the counter load pulses into synchronism with the time base.

The Synchronizer and the generator form a variation of an M/N phase lock loop. The time base reference (1 MHz) divided by M is compared in the Null Phase Detector to the signal frequency divided by N. In operation, this is 1 MHz ÷ 64 ÷ 10 ÷ 10 ÷ 100 and the signal frequency ÷ 64 ÷ Count Down Preset.

NOTE

Count Down Preset is the complete number shown in Display (without decimal point). The down-counter produces one Counter Load pulse each time it counts to zero from the preset number.

If the two frequencies differ, the RF signal is tuned to bring the signals into synchronism. M is a fixed number and N is self-programmed since it is determined by the count just prior to entering phase lock.

The Low-Pass Filter is a sample-and-hold type that samples the phase detector voltage. The voltage is sampled during the time base pulse and stored between pulses. If the phase detector voltage exceeds preset limits, an error condition occurs, and the counter reverts to the count-up mode. The error also switches on a 2 Hz Flash Oscillator causing the Display to blink (an indication that phase lock has been broken).

When LOCK + 500 Hz is depressed, operation is the same as normal phase lock except for the use of the Pulse Swallowing Circuit in the RF Scaler. The Pulse Swallowing Circuit blocks one pulse to the final ÷ 2 stage every count-down cycle. During normal phase lock, the least significant digit in the Display represents kilohertz (it is, in fact, the ones digit in the counter after RF scaling). Now suppose that one pulse is blocked from the down-counter each count cycle. The count to zero would take one count longer. The Phase Lock Circuits would sense this condition as a 1 kHz error and tune the signal frequency 1 kHz higher. In actual operation, however, the "pulse swallowing" occurs before the final ÷ 2 stage in the RF Scaler. Therefore the final count takes only 1/2 count longer. The Phase Lock Circuits sense a 500 Hz error and drive the signal frequency 500 Hz higher. A new least significant digit (5) is shown on the Display to indicate the increase of 500 Hz.

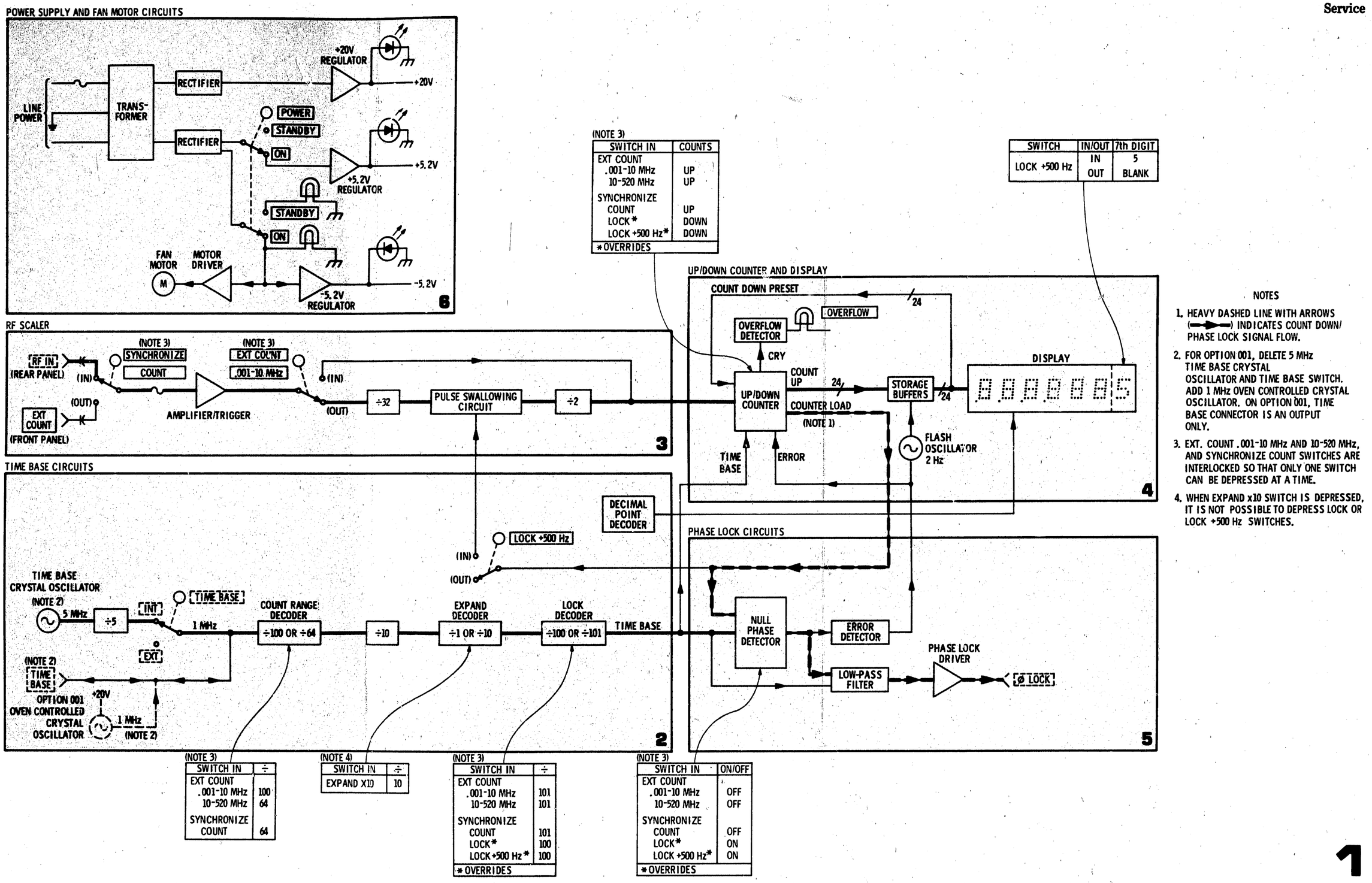
NOTE

The additional digit 5 is not part of the Count Down Preset frequency.

Power Supply and Fan Motor Circuits

The instrument has three regulated power supplies: +20V, +5.2V, and —5.2V. A lighted LED on each supply indicates that the supply is working. With the POWER switch in STANDBY (but with the line cord energized) the +20V supply is on.

The cooling fan is driven from a speed regulating circuit.



NOTES

1. HEAVY DASHED LINE WITH ARROWS (▬▶▬) INDICATES COUNT DOWN/ PHASE LOCK SIGNAL FLOW.
2. FOR OPTION 001, DELETE 5 MHz TIME BASE CRYSTAL OSCILLATOR AND TIME BASE SWITCH. ADD 1 MHz OVEN CONTROLLED CRYSTAL OSCILLATOR. ON OPTION 001, TIME BASE CONNECTOR IS AN OUTPUT ONLY.
3. EXT. COUNT .001-10 MHz AND 10-520 MHz, AND SYNCHRONIZE COUNT SWITCHES ARE INTERLOCKED SO THAT ONLY ONE SWITCH CAN BE DEPRESSED AT A TIME.
4. WHEN EXPAND x10 SWITCH IS DEPRESSED, IT IS NOT POSSIBLE TO DEPRESS LOCK OR LOCK +500 Hz SWITCHES.

Figure 8-12. Overall Block Diagram

SERVICE SHEET 2

PRINCIPLES OF OPERATION

General

The A1A3 Time Base Board Assembly contains the internal time base reference and divider circuits. The time base signal is divided down to the period required to gate the counter for the selected input mode (EXT COUNT: .001—10 MHz, 10—520 MHz or SYNCHRONIZE COUNT), expand mode or counter mode (count or phase lock). The assembly also contains the Decimal Point Decoder. All logic and power supply inputs to the board are low-pass filtered to prevent RF leakage.

Time Base Reference Crystal Oscillator (A1A3)

The standard internal time base reference oscillator A1A3Y1 is a 5 MHz crystal oscillator. A mechanical adjustment permits fine tuning. The oscillator output is divided by five (to 1 MHz) and drives additional dividers and an output jack through OR gate U1D. The signal passes through U1D only when pin 13 is low. The TIME BASE switch must be set to INT (standard instrument only).

With the TIME BASE switch set to EXT, a 1 MHz reference signal can be applied to the external TIME BASE jack. For Option 001, a thermally stabilized (in a proportional controlled oven) 1 MHz signal from chassis part Y1 is applied at the output of U1D (both A1A3Y1 and the TIME BASE switch are eliminated in Option 001).

Buffer amplifier Q5 assures that the reference signal is capable of driving divider U5.

Time Base Dividers (A1A3)

Dividers U5 thru U11 are programmed by the front panel switches to give the correct time base frequency for the mode selected. At TP5 the time base division (M), frequency (f) and period (T) are as follows:

Count Mode	Locked	Unlocked	Unlocked With Expand x10
.001–10	M = 100,000 f = 10.0 Hz T= 100 ms	M = 101,000 f = 9.9 Hz T ≈ 101 ms	M = 1,010,000 f = 0.99 Hz T ≈ 1010 ms
10–520 or SYNCHRONIZE COUNT	M = 64,000 f = 15.625 Hz T = 64.0 ms	M =64,640 f ≈ 15.47 Hz T = 64.64 ms	M =646,400 f ≈ 1.547 Hz T = 646.4 ms

÷100, ÷ 64 (A1A3)

U5 and U6 divide the 1 MHz input by 100 (EXT COUNT: .001—10 mode) or by 64 (10—520 or SYNCHRONIZE COUNT modes). To divide by 64 the dividers are preset to 36; then they count up to 99. On the next count they are again preset to 36. Thus, the counters are preset after every 64 counts. To divide by 100 the counters are preset to 00.

U5 and U6 are synchronous, presettable decade counters, that count only when the count enable (CE) is high. The counters load (preset) when the T input goes high if CE is high and load (LD) is low. On the count of nine the transfer carry (TC) goes high if CE is high. If the .001-10 switch is out (i.e., 10—520 or SYNCHRONIZE COUNT has been selected) data (or preset) inputs D_B and D_C of U5 and D_A and D_B of U6 are high (all other D inputs low). This corresponds to a six in U5 and a three in U6 or 36 total.

SERVICE SHEET 2 (cont'd)

When the count reaches 99, TC of U5 is high, enabling U6. This allows TC of U6 to go high and puts a low on the LD of both U5 and U6 (through inverter U2B). The next count (into T) initiates the load, and the counters preset to 36. The counters then count up from 36 to 99 and the sequence repeats. If .001—10 mode is selected, the operation is similar except that all data inputs (D_A thru D_D) of U5 and U6 are low. This causes 00 to be preset instead of 36.

÷10 and Expand Decoder

U7 is normally a ÷10 counter. (However, if TP3 is connected to +5.2V it becomes a ÷1. This capability is used only for testing to increase time base frequency. This makes it easier to view functions on an oscilloscope.) The reset-to-nine (R_9, pin 7) input of U7 is normally disabled by a low through R14. Thus U7 divides by ten. If instead R_9 is high, the ÷1 sequence is initiated.

Assume U7 is at the count of nine. A low-going pulse at input T_A clocks U7 to zero (the next count after nine). When T_A goes high, U7 is not clocked, but the pulse is coupled across C27 and momentarily raises pin 6 to a high (normally low through R12). This resets U7 to a nine. The sequence then repeats. The result is that Q_D follows T_A instead of being divided by ten.

Operation of U8 is similar to U7. When in the EXPAND x10 mode, pin 7 of U8 is held low (through inverter U2A), and U8 functions as a ÷10. If EXPAND x10 switch is out, pin 7 is high and U8 divides by one. A mechanical interlock prevents the use of EXPAND x10 while locked.

Lock Decoder (A1A3)

U9, U10, and U11A function as a ÷101 (count mode) or a ÷100 (lock mode). In the ÷101 mode, TP5 is low for 100 counts (into T_A of U9) and high for one count. In the divide by 100 mode TP5 is low except for 0.5 μs every 100th count.

÷101 (Count Mode). In ÷101 mode, the Lock line is low and the reset-to-zero (R_0) gates of U9 and U10 are disabled. The reset-to-nine (R_9) gates are held low at pin 7 by R18 through OR gate U1C. Assume initially that Q_A of U11A is low. U9 and U10 count up normally until the count of 99. On the 100th count (into T_A of U9), U9 and U10 clock to the next count (zero). This causes Q_D of U10 to go low which clocks Q_A of U11A to a high (thru U1A). This high is coupled across C29 and momentarily raises U1C to a high which resets U9 and U10 to 99. The next count clocks U9 and U10 again to zero and Q_A of U11A returns low. Thus Q_A of U11A is low for 100 counts and high for one count.

÷100 (lock Mode). In ÷100 mode, the Lock line is high putting a high on pin 3 of the R_0 gates of U9 and U10. Assume initially that Q_A of U11A is low. This holds pin 2 of the R_0 gates low, thus disabling them. The R_9 gates are held low at pin 7 by R18 through OR gate U1C. U9 and U10 count up normally until the count of 99. On the 100th count (into T_A of U9), U9 and U10 clock to the next count (zero). This causes Q_D of U10 to go low and clocks

SERVICE SHEET 2 (cont'd)

Q_A of U11A to a high. This causes pin 2 of R_0 gates to be high. The high is also coupled across C29 and monentarily raises U1C to a high. Thus U9 and U10 have a simultaneous reset to zero and nine. However, the reset to nine predominates and U9 and U10 reset to 99. Approximately 0.5 μs later the high across R18 returns low, and the reset to nine is released. Since a reset to zero is still present, U9 and U10 reset to zero. This clocks U11A back to a low. Thus Q_A of U11A is low for almost 100 counts and high for 0.5 μs.

After being inverted by U2F the Q_A output of U11A becomes the time base.

Decimal Point Decoder (A1A3)

The Decimal Point Decoder decodes the front panel switch functions to position the decimal in the display. U3 and U2C form a combinational logic circuit with the following truth table:

.001–10	EXPAND x10	DP4	DP5	DP6	DP7
In	In	H	H	H	L*
In	Out	H	H	L*	H
Out	In	H	L*	H	H
Out	Out	L*	H	H	H

*Lights decimal point.

TTL to ECL Converters (A1A3)

U1B and Q6 convert the positive TTL logic levels to negative ECL logic levels. Q6 is controlled by the .001—10 switch to cause a logic inversion. U1B is enabled only for LOCK +500 Hz.

SERVICE SHEET 2 (cont'd)

TROUBLESHOOTING

DESCRIPTION:

The Time Base signal is generated by dividing down a reference signal. The circuits are troubleshot by first checking the reference and then the outputs from the various stages of the divider chain. A low capacitance probe should be used with both the oscilloscope and high impedance counter to make the measurements. This will minimize the effects of capacitive loading on the logic outputs which can cause multiple triggering of the counter. For frequencies below 1 kHz, a periodic measurement is easier than measuring frequency.

TEST EQUIPMENT:

Frequency Counter ..... HP 5327C
Oscilloscope ..... HP 1820C/1801A/182C
10:1 Voltage Divider Probe (2 preferred) ..... HP 10004D

PROCEDURE:

1. Remove instrument's front panel and top cover.

SERVICE SHEET 2 (cont'd)

2. Remove counter top cover and A1A2 Counter/Display Assembly with riser board. Remove riser board and return A1A2 Assembly to counter on an extender board (see Service Sheet A).

3. Set controls as follows (see Figure 8-11):

POWER ..... ON (In)
EXT COUNT: .001—10 MHz ..... In
LOCK ..... Out
LOCK +500 Hz ..... Out
EXPAND x10 ..... Out

TIME BASE (rear panel except Option 001) ..... INT

4. Go to the section in Table 8-2 which describes troubleshooting for the suspected area. Start at the beginning of the section and follow the steps in sequence. **Before beginning another section, return controls to positions described in step 3.**

Table 8-2. Time Base Circuits Troubleshooting (1 of 2)

Step	Instructions	Normal Indication	If Indication Abnormal
A.	**Time Base (A1A3, Standard Instrument only)**		
1	Measure at TP6.	Square wave, 4 to 6 Vp-p, 5,000,000 ±10 Hz.	Check A1A3Y1 and +5.2V line. If frequency is only slightly off, perform Internal Time Base Reference Adjustment in Section 5.
2	Measure output of U11B(11)	TTL pulses, 1 MHz	Check U11B.
3	Measure TIME BASE output (rear panel)	Square wave, 2.5 to 4 Vp-p, 1 MHz	Check U1D, TIME BASE output lines, and TIME BASE switch line. Pin 13 of U1D should be low.
4	Measure at Q5(c).	TTL pulses, 1 MHz.	Check Q5 and associated components.
5	Set switches as follows. Measure at TP2 only.	TP2, U6 (15), U2B (4): .001–10 MHz: In; 10–520 MHz or SYNCHRONIZE COUNT: Out U5(15): TTL,10kHz: In; TTL, 15.625 kHz: Out; TTL,100kHz: Out; TTL, 109.375 kHz: In U5(4): L; H	Measure U5(4), U5(15), and U28(4). Check U2B, U5, U6, and lines to D inputs of U5 and U6.
6	Depress .001–10 MHz. Measure at U7(11).	TTL pulses, 1 kHz	Check U7.
7	Short TP3 to +4.5V (available at A1A2A1R3; see Service Sheet 4). Measure at U7(11).	TTL pulses, 10 kHz	Check U7, C27, and R12.

Table 8-2. Time Base Circuits Troubleshooting (2 of 2)

Step	Instructions	Normal Indication	If Indication Abnormal
8	Measure at TP4.	TTL pulses, 10 kHz	Check U8, C28, R15, and line to U8 (7; should be high).
9	Depress EXPAND x10. Measure at TP4.	TTL pulses, 1 kHz	Check U8 and line to U8(7; should be low)
10	Release EXPAND x10. Measure at TP5.	TTL pulses, ≈99.01 Hz or 10.1 ms. If correct go to step 17.	Continue with steps 11 to 16.
11	Ground U1C(8). Measure at U9(11).	TTL pulses, 1 kHz or 1 ms.	Check U9.
12	Measure at U10(11) and U1A(3).	TTL pulses, 100 Hz or 10 ms.	Check U10 and U1A.
13	Measure at TP5 and U2F(12).	TTL square wave, 50 Hz or 20 ms.	Check U11A and U2F.
14	Remove ground on U1C(8). Short U1C(8) to +4.5V. Measure U9 and U10 Q outputs.	Binary nines; i.e., Q_A and Q_D TTL high Q_B and Q_C TTL low.	Check U9 and U10.
15	Remove short on U1C(8). Short TP5 to +4.5V. Short A1A2A1TP4 (see Service Sheet 5) to ground. Depress LOCK. Measure U9 and U10 Q outputs.	All outputs TTL low.	Check U9 and U10.
16	Remove all shorts. Check U1C and associated components.		
17	Ground A1A21TP4 (see Service Sheet 5) Release, then depress LOCK. Measure at TP5.	TTL pulses, 100 Hz or 10 ms (≈ 0.5 μs wide). NOTE: Pulses will be very faint.	Check U10(3) for high. If low, see Service Sheet 5: Count-to-Lock Switching. If high, release LOCK and continue with steps 11 to 16.
S.	**Time Base (A1A3, Option 001 only)**		
1	Measure at U1D(11).	Approximately square wave, 1.5 to 2.5 Vp-p, 1,000,000 ±1 Hz.	Check chassis part Y1 supply and signal lines. If slight frequency error only, perform Internal Time Base Reference Adjustment in Section 5.
2	Perform steps 4 thru 17 in Section A.		
C.	**Logic Translators (A1A3)**		
1	Measure at Q6(c).	–0.3 to –0.5 Vdc.	Check Q6, associated components, and line from Q6(C) into A1A1 RF Scaler Board Assembly.
2	Depress 10–520 MHz. Measure at Q6(c).	–5.0 to –5.2 Vdc.	
3	Measure at U1B(6).	TTL high.	Check U1B and lines to U1B (4 and 5; should be high).
4	Ground A1A2A1TP4 (see Service Sheet 5) Connect TIME BASE output (rear panel) to EXT COUNT input. Depress LOCK +500 Hz. Depress .001–10 MHz. Measure at anode of CR2.	0V, ←2 μs→, –4V (Pin 5 U1B should be low).	Check U1B, C26, R13, CR2 and line from anode of CR2. Perform Counter-Count Down (Locked) Mode Troubleshooting, Service Sheet 4.
D.	**Decimal Point Decoder (A1A3)**		
1	Set switches as follows. Measure logic level indicated.	Refer to entire table for normal logic levels.	Check U2, U3, and switching lines. Check A1U4 to U7 (see Service Sheet 4).

.001–10 MHz	10–520 MHz or SYNCHRONIZE COUNT	EXPAND x10
In	Out	Out
In	Out	In
Out	In	In
Out	In	Out

U2A(1)	U2A(2) U3A(2) U3D(13)	U2C(5) U3C(9) U3D(12)	U2C(6) U3A(1) U3B(5)	U3C(10) U3D(11) DP4	U3C(8) DP5	U3A(3) U3B(4) DP6	U3B(6) DP7
L	H	L	H	H	H	L	H
H	L	L	H	H	H	H	L
H	L	H	L	L	H	H	H
H	L	H	L	L	H	H	H

Overall Block Diagram
SERVICE SHEET 1

P/O A1A3 ASSEMBLY

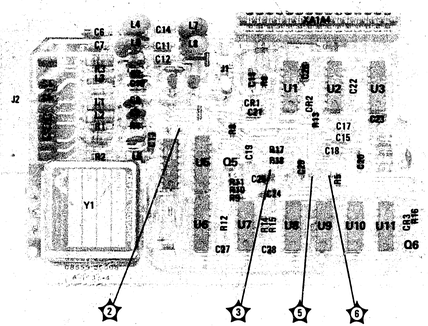
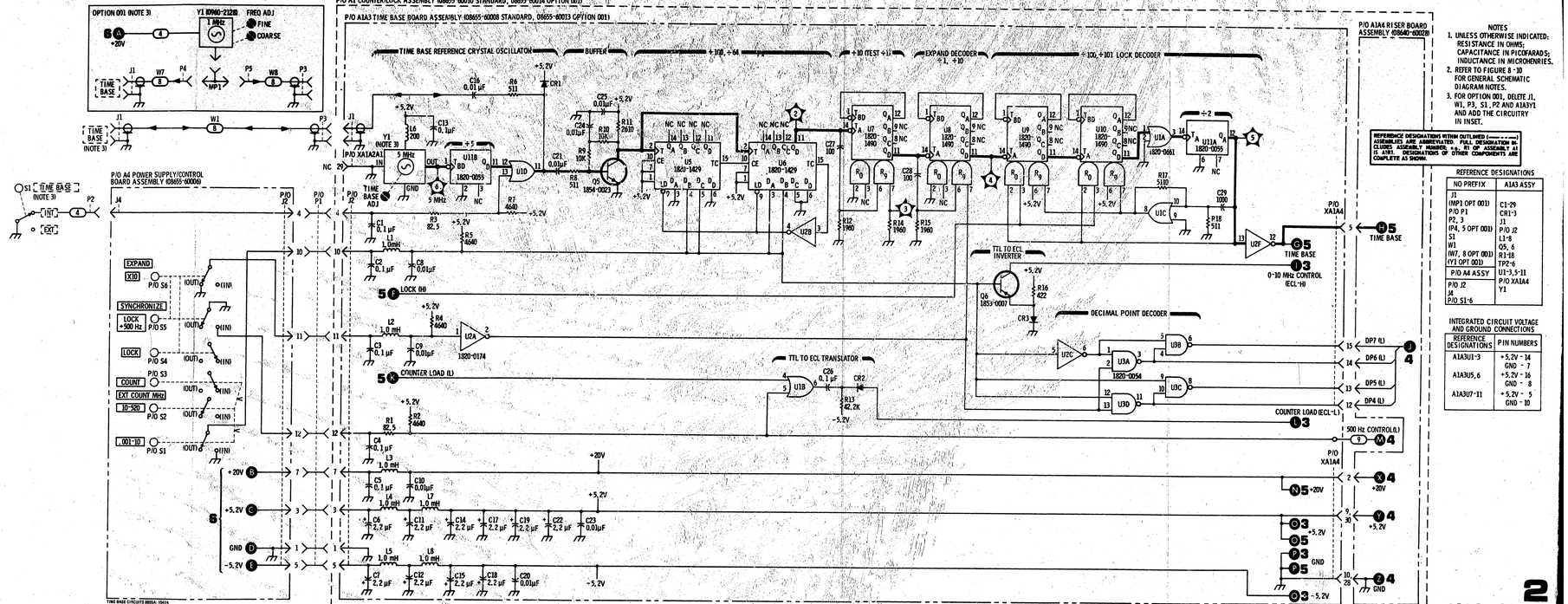


Figure 8-13. P/O A1A3 Time Base Roard Assembly (Time Base) Component Locations



NOTES
1. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS; CAPACITANCE IN PICOFARADS; INDUCTANCE IN MICROHENRIES.
2. REFER TO FIGURE 8 - 10 FOR GENERAL SCHEMATIC DIAGRAM NOTES.
3. FOR OPTION 001, DELETE J1, W1, P3, S1, P2 AND A1A3Y1 AND ADD THE CIRCUITRY IN INSET.

REFERENCE DESIGNATIONS WITHIN OUTLINED (———) ARE ASSEMBLY NUMBERS. FULL DESIGNATION INCLUDES ASSEMBLY NUMBER, e.g., R1 OF ASSEMBLY A1 IS A1R1. DESIGNATIONS OF OTHER COMPONENTS ARE COMPLETE AS SHOWN.

REFERENCE DESIGNATIONS	
NO PREFIX	A1A3 ASSY
J1 (MP1 OPT 001)	C1-29
P/O P1	CR1-3
P2, 3 (P4, 5 OPT 001)	J1
S1	P/O J2
W1 (W7, 8 OPT 001)	L1-8
(Y1 OPT 001)	Q5, 6
P/O A4 ASSY	R1-18
P/O J2	TP2-6
J4	U1-3, 5-11
P/O S1-6	P/O XA1A4
	Y1

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
A1A3U1-3	+5.2V - 14 GND - 7
A1A3U5, 6	+5.2V - 16 GND - 8
A1A3U7-11	+5.2V - 5 GND - 10

2
A1A3, A1A4, A4

Figure 8-14. Time Base Circuits Schematic Diagram

SERVICE SHEET 3

PRINCIPLES OF OPERATION

General

The A1A1 RF Scaler Board Assembly switches the RF signal path, conditions the signal waveform, prescales (divides) the signal, and in the case of LOCK +500 Hz provides pulse swallowing. The circuit is the high frequency portion of the counter.

Isolation Circuit (A1A1A1)

When SYNCHRONIZE COUNT switch is in, PIN diode CR1 is forward biased and presents a low series impedance to rear panel RF input. With SYNCHRONIZE COUNT out, CR1 blocks the rear panel input signal to prevent crosstalk with a front panel input signal at relay A1A1K1.

Input Circuits (A1A1)

RF relay K1 routes the front or rear panel signals to the scaler input. Resistor R1 terminates the front panel input when SYNCHRONIZE COUNT button is in. Both input circuits have dc-blocking capacitors. Both inputs are protected by a common fuse (A1F1) as well as by diodes CR1 and CR2 which give short-term protection. High-speed amplifiers U5 and U6 act as an Amplifier/Trigger producing fast rising pulses at the output regardless of the shape of the input signal. This is needed to drive the high-speed logic that follows. U5 and U6 have complementary outputs (only one is used at the output of U6).

RF Dividers (A1A1)

U1, A1U2, and U4B form a ÷64. If 10—520 or SYNCHRONIZE COUNT modes have been selected, (.001—10 button is out) the 0—10 MHz Control line is low (ECL). This enables the OR input of U1 allowing the pulses from U6 to be divided by two and then by 32 in A1U2. Q2 shifts the EECL logic level to an ECL level by its base-emitter voltage drop. A final ÷2 is done in U4B which is a D flip-flop wired to divide by two (i.e., $\overline{Q}$ connected to D). The OR input of U4B is enabled by a low from Q of U4A (discussed under Pulse Swallowing Circuit). The prescaled signal then passes through NOR gate U3B. U3B is enabled by a low input at U3D, a high at pin 10 of U3C and consequently a low at pin 5 of U3B. The undivided RF signal also passes through Q1 but is blocked by U3C (pin 10 of U3C is high disabling the gate).

If .001—10 button is in, the 0—10 MHz Control line is high (i.e., approximately ground) and disables the OR input of U1. The signal then passes through Q1, U3C and U3B. U3B is enabled by the high on the reset (R) input of U4B which causes the Q output to go low. U3C is enabled by the high input and low output of U3D. R19 is a positive feedback resistor around U3C and U3B which speeds up the transition between logic states. The signal then passes through A1A3Q4 which converts the negative signal levels to positive TTL levels.

Pulse Swallowing Circuit (A1A1)

When LOCK +500 Hz is depressed, the Pulse Swallowing Circuits are enabled each time Counter Load line goes low. This circuit

SERVICE SHEET 3 (Cont'd)

blocks one pulse to the final ÷2 (U4B) of the RF scaler during each cycle of the down-counter. Thus, after the final ÷2, the signal entering the down counter takes 1/2 count longer to reach zero.

In LOCK +500 Hz mode, the Counter Load signal controls the operation of the Pulse Swallowing Circuit. Initially, the input to NOR gate U3A is held high (ground through R7) and the output is low. Pulses entering pin 9 of U4A clock the low at the D input to the Q output which enables U4B (its usual mode of operation). Also, the low at Q of U4A cuts off Q3, putting a low at pin 2 of U3A.

When the Counter Load signal goes low, the output of U3A goes high (both inputs are now low) which puts a high at the D input of U4A. This causes the next clock pulse into U4A to clock its Q output to a high, disabling the input to U4B. The high from U4A also puts a high (through Q3) on pin 2 of U3A causing its output and the D input of U4A to return low (see note). The next clock pulse does not clock U4B since it is disabled. However, it does clock the low at D of U4A to its Q output and thus enables U4B again.

NOTE

The high input at pin 2 of U3A is stretched by C10 to hold the output low until Counter Load returns high. This ensures that one and only one pulse is blocked (swallowed) during the Counter Load low.

In summary, when the Counter Load line goes low, the next clock pulse disables U4B. The following clock pulse is blocked by U4B but re-enables it. U4B then resumes normal operation.

TROUBLESHOOTING

DESCRIPTION:

The counter input circuits consist of the counter front end, RF scaler dividers, and pulse swallowing circuit. The circuits are troubleshot by tracing the signal from input to output. The pulse swallowing circuit is checked by forcing it to function as an additional ÷2 in the RF scaler.

Because of the low signal levels of the high-speed logic devices, an oscilloscope probe cannot usually be used with the frequency counter. The counter sensitivity or trigger level may need occasional readjustment to prevent multiple triggering.

TEST EQUIPMENT:

Frequency Counter . . . . . HP 5327C
Oscilloscope . . . . . HP 1820C/1801A/182C

PROCEDURE

1. Remove instrument's front panel and top cover.
2. Remove counter top cover, A1A2 Counter/Display Assembly and the cover to A1A1 RF Scaler Board Assembly (see

SERVICE SHEET 3 (Cont'd)

Service Sheet A). Remove riser board and return A1A2 assembly to counter on an extender board.

3. Set controls as follows (see Figure 8-11):

POWER . . . . . ON (In)
SYNCHRONIZE COUNT . . . . . In
LOCK . . . . . Out
LOCK +500 Hz . . . . . Out
EXPAND x10 . . . . . Out

TIME BASE (rear panel except Option 001) . . . . . INT

4. Go to the section in Table 8-3 which describes troubleshooting for the suspected area. Start at the beginning of the section and follow the steps in sequence. **Before beginning another section, return controls to positions described in step 3.**

SERVICE SHEET 3 (Cont'd) **Table 8-3. RF Scaler Circuits Troubleshooting**

Step	Instructions	Normal Indication	If Indication Abnormal
A.	**Input Circuits (A1A1)**		
1	Connect TIME BASE output (rear panel) to RF IN (rear panel). Measure at U5(2).	Pulses, 150 to 250 mVp-p, 1 MHz	Check cabling to RF IN jack, A1A1A1, K1, drive to K1, A1F1, and input to U5. If good, see Service Sheet 2: Time Base.
2	Connect TIME BASE output to EXT COUNT input. Depress 10—520 MHz. Measure at U5(2).	Pulses, 150 to 250 mVp-p, 1 MHz	Check cabling to EXT COUNT jack, K1, and drive to K1.
3	Measure at U5(4).	Pulses, 400 to 500 mVp-p, 1 MHz	Check U5 and associated components.
4	Measure at U6(4).	Pulses, 500 to 700 mVp-p, 1 MHz	Check U6 and associated components.
B.	**Dividers (A1A1)**		
1	Connect TIME BASE output (rear panel to EXT COUNT. Depress 10—520 MHz. Measure at U1(6).	Square wave, 600 to 700 mVp-p, 500 kHz.	Check U1.
2	Measure at Q2(e).	Square wave, 600 to 700 mVp-p, 31.25 kHz	Check A1U2, Q2, and associated components.
3	Measure at Q1(e).	Pulses, 500 to 700 mVp-p, 1 MHz.	Check Q1 and associated components.
4	Measure at U4B(15).	Square wave, 900 to 1000 mVp-p. 15.625 kHz. (U4B pin 13 should be ECL low).	Check U4B.
5	Measure at U3B(6).	Square wave, 700 to 800 mVp-p, 15.625 kHz (U3B pin 5 should be ECL low)	Check U3B.
6	Depress .001—10 MHz. Measure at U3B(6).	Pulses, 900 to 1000 mVp-p, 1 MHz. (U3D pin 12 should be ECL high)	Check U3 and associated components.
7	Measure at A1A3Q4(c).	Pulses, 4 to 5 Vp-p, 1 MHz.	Check A1A3Q4 and associated components.
C.	**Pulse Swallowing Circuit (A1A1)**		
1	Depress 10—520 MHz. Ground A1A2A1TP4 (see Service Sheet 5). Short leads of A1A3R13 (see Service Sheet 2). Measure at U3B(6).	Square wave, 700 to 800 mV p-p, 7.8125 kHz.	Check U3A, U4, Q3, and associated components. 7.8125 kHz waveforms should appear at U4A(7), U4A(2), U3A(3), and Q3(e).

Time Base Circuits
A1A3, A1A4, A4
SERVICE SHEET 2

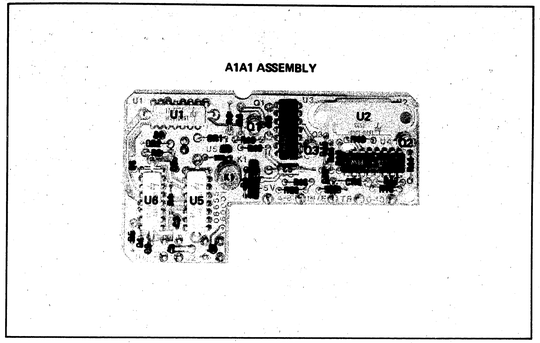


Figure 8-15. A1A1 Scaler Board Assembly Component Locations

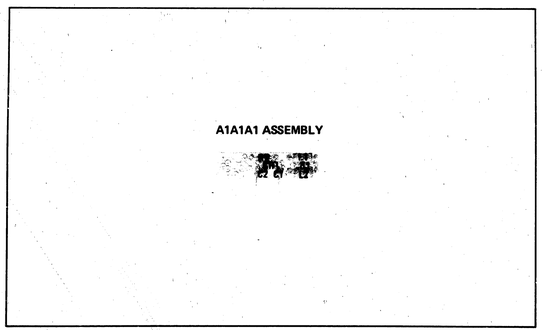


Figure 8-16. A1A1A1 Isolation Board Assembly Component Locations

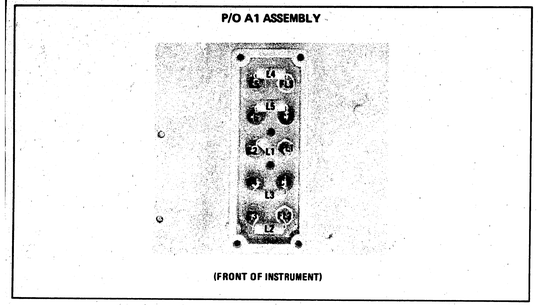


Figure 8-17. P/O A1 Counter/Lock Assembly (Filters) Component Locations

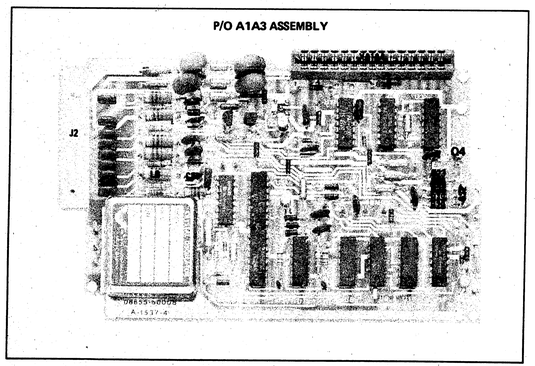
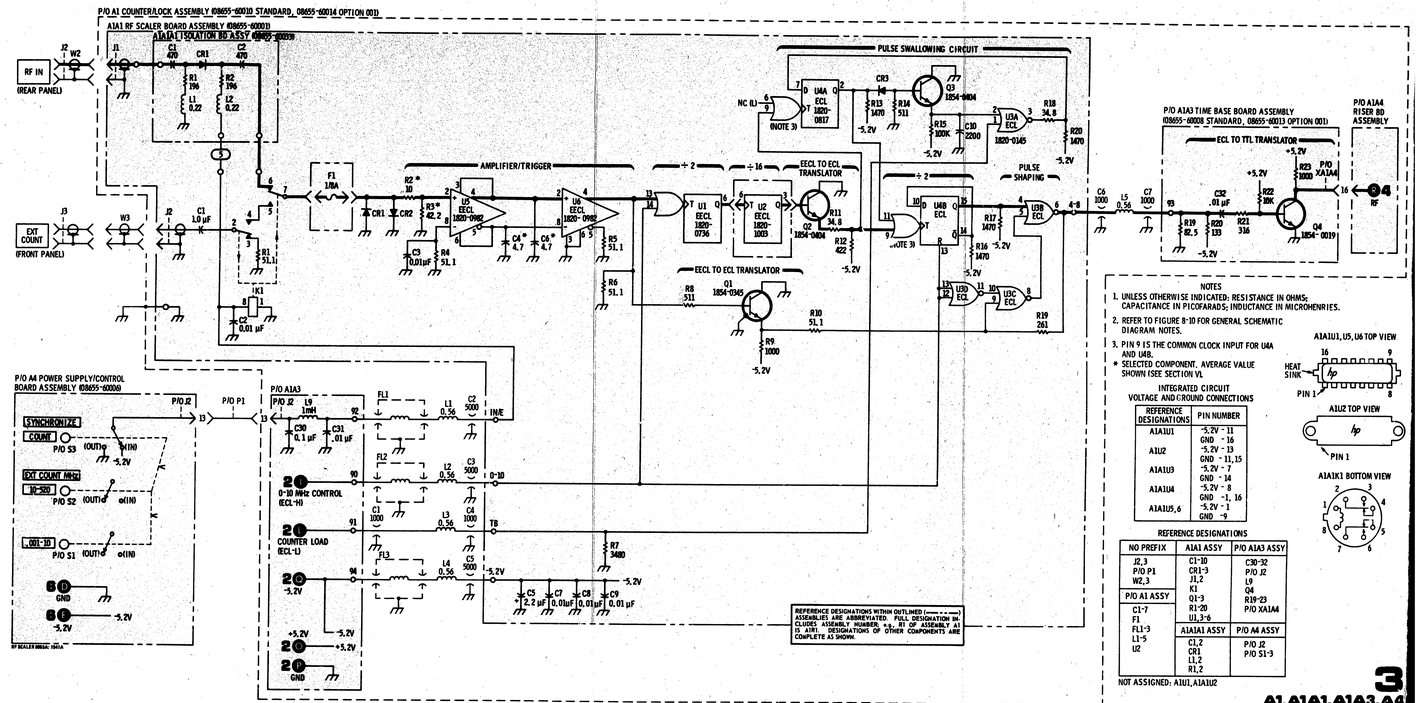


Figure 8-18. P/O A1A3 Time Base Board Assembly (Translator) Comoonent Locations



3
A1, A1A1, A1A3, A4

Figure 8-19. RF Scaler Schematic Diagram

SERVICE SHEET 4

GENERAL

Troubleshooting information for the entire Up/Down Counter and Display is presented on this page and is keyed to the detailed schematic. However, most of the circuit operation is described on Service Sheet 4A and is keyed to simplified circuit diagrams. Only the Flash Oscillator circuit is described in detail here.

PRINCIPLES OF OPERATION

Flash Oscillator (A1A2A1)

When a phase lock error is detected, a 2 Hz Flash Oscillator is turned on to blink the Display. Transistors Q5 and Q4 form a two-stage astable multivibrator. A high on the ERROR line holds collector resistor R7 at about 3V, and the oscillator is biased on. The frequency of oscillation is determined by the time constants of R2, C9 and R5, C8. The collector of Q4 switches transistor Q3 which switches the Vcc supply to the Storage Buffers U7 through U12. With an open at the Vcc Supply, the Storage Buffer outputs are opened which represents a high to each display input. The displays generate a blank when all inputs are high. When no error exists Q3 is held on by Q4 which is also on, and Vcc is at 5V.

TROUBLESHOOTING

DESCRIPTION

The counter functions as a six-decade up counter when unlocked or a presettable down counter when locked. The counter is troubleshot separately for the two modes. In the count up mode the count, clear, and output transfer actions are checked. In the count down mode the count down, preset, and stall count actions are checked. A low capacitance probe should be used with both the oscilloscope and high impedance counter to make the measurements. This will minimize the effects of capacitive loading on the logic outputs which can cause multiple triggering of the counter. Both period and frequency measurements will be made.

TEST EQUIPMENT

Frequency Counter ..... HP 5327C
Oscilloscope ..... HP 1820C/1801A/182C
Test Oscillator ..... HP 651B
Voltage Divider Probe (2 preferred) ..... HP 10004D

PROCEDURE

1. Remove instrument's front panel and top cover.

2. Remove counter top cover and A1A2 Counter/Display Assembly with riser board. Remove riser board and return A1A2 Assembly to counter on an extender board (see Service Sheet A).

3. Set controls as follows (see Figure 8-11):

POWER ..... ON (In)
EXT COUNT: .001–10 MHz ..... In
LOCK ..... Out
LOCK +500 Hz ..... Out
EXPAND x10 ..... Out
TIME BASE (rear panel except Option 001) ..... INT

4. Go to the section in Table 8-4 which describes troubleshooting for the suspected area. Start at the beginning of the section and follow the steps in sequence. **Before beginning another section, return controls to positions described in step 3.**

Table 8-4. Up/Down Counter and Display Troubleshooting (1 of 3)

Step	Instructions	Normal Indication	If Indication Abnormal
A.	**Shaping (A1A2A1)**		
1	Connect 10 MHz, 1 Vrms signal to EXT COUNT. Measure at U13A(3).	TTL pulses, 10 MHz, 30 ns wide	Check U2B, U2C, U13A, U14D, U15A, and associated components. 10 MHz square wave should appear at U15A(3), U2B(6), U2C(8), and U14D(1). Propagation delay through U2C, U14D, R6, and C10 determines pulse width.
B.	**Counter-Count Up Mode (A1A2A1)**		
1	Connect 10 MHz, 1 Vrms signal to EXT COUNT. Measure at U15B(6).	TTL pulses (low going), 10 MHz, 50 ns wide	Check U1A, U2D, U13A, U14B, U15B, and U17D. 10 MHz pulses should appear at U2D(11), U1A(6), U14B(6) and U15B(6). U2D(13), U17D(12), and U17D(13) should be high.
2	Short A1A3TP3 (see Service Sheet 2) to +4.5V (available at R3). Measure at TP2. NOTE: Decimal point is now incorrect.	TTL pulses (low going) ≈990 Hz or 1.01 ms, 30 ns wide. NOTE: Oscilloscope trace will be very faint.	Check U4E, U16B, and associated components.
3	Measure at U17C(8).	TTL pulses ≈990 Hz or 1.01 ms, 30 ns wide. NOTE: Oscilloscope trace will be very faint.	Check U17C and associated components.
4	Short U17C (8, CLEAR COUNTERS) to +4.5V (available at R3).	Display reads 00.0000	Check Counter (U19 to U24), Storage Buffer (U7 to U12), and Display (A1U4 to A1U9) associated with incorrect digit.
5	Remove short from U17C(8). Connect external signal to input of external frequency counter as well as to EXT COUNT. Set frequency counter time base to 10 ms. Set test oscillator frequency for displays shown below and note frequency counter reading. Display 0.99999 0.88888 0.77777 0.66666 0.55555 0.44444 0.33333 0.22222 0.11111	Display and frequency counter frequencies agree ±2 counts except that Display shows decimal point shifted one space to left.	If Display is in error by one digit only, check Storage Buffer (U7 to U12), Display (A1U4 to U9) and Counter (U19 to U24) associated with the digit. If Display is in error by more than one digit, check Counter associated with the first wrong digit from right (e.g., frequency counter reads 07.444 and Display reads 04.4444, check U21). Pin 4 of Counters U19 to U24 (CD input) should be high

Table 8-4. Up/Down Counter and Display Troubleshooting (2 of 3)

Step	Instructions	Normal Indication	If Indication Abnormal
6	Depress EXPAND x10. Repeat step 5 for the following displays. Display .1XXXXX .2XXXXX .3XXXXX .4XXXXX .5XXXXX .6XXXXX .7XXXXX .8XXXXX .9XXXXX	Most significant digit of Display and frequency counter agree except for decimal point.	Check U7, U19, and A1U9.
C.	**Counter-Count Down Mode (A1A2A1)**		
1	Connect 10 MHz, 1 Vrms signal to EXT COUNT. In addition connect this signal to frequency counter's external time base oscillator input. Set frequency counter's time base to external. Ground TP4 (see Service Sheet 5). Short leads of L2. Depress LOCK. Measure at U19(13). If incorrect also measure pins 4 of U19 to U24.	TTL pulses with exact frequencies: U19(13) 10 Hz U24(4) 10 MHz U23(4) 1 MHz U22(4) 100 kHz U21(4) 10 kHz U20(4) 1 kHz U19(4) 100 Hz U19(13) 10 Hz pulses 40 ns wide pulses 100 ns apart 9 pulses TTL high TTL low pulse bursts 2 µs period	Proceed with remaining measurements. Check U14C. U14C(9) should be low. Check U2A, U13C, U13D, U24, U25A, and U25D. U13C(10) and U24(5) should be high. Check U6A, U18B, U23, and U27A. U23(5) should be high. Check U6B, U18A, U22, and U27D. U22(5) should be high. Check U6D, U18C, U21, and U27B. U21(5) should be high. Check U6C, U18D, U20, and U27C. U20(5) should be high. Check U19. U19(5) should be high.
2	Remove short on L2. Release Lock. Set oscillator to approximately 200 Hz, fine tune for display of 0.00020 and depress LOCK. Increase frequency to 10 MHz. Measure at U17B(6).		Measure at U17A(2); if not high, see Service Sheet 5: Lock Switching. If pulse burst period incorrect, continue on with steps 3 to 5. Otherwise, check U18, U14C, U17A, U17B, and U28. TTL pulses, 100 ns period should appear at U17B(4). TTL square wave, 0.2 µs period should appear at U17A(1), U17A(3), and U17B(5).

RF Scaler
A1, A1A1, A1A3, A4
◀ SERVICE SHEET 3

Table 8-4. Up/Down Counter and Display Troubleshooting (3 of 3)

Step	Instructions	Normal Indications	If Indication Abnormal
3	Measure at U25C(10).	TTL pulses (low going), 2 µs period.	Check U25C and associated components.
4	Release LOCK. Remove signal from EXT COUNT. Ground U24(11).	Display reads 00.0000.	
5	Short A1A3TP3 (see Service Sheet 2) to +4.5V (available at R3). NOTE: Decimal point now incorrect. Remove ground from U24(11). Reconnect signal to EXT COUNT. Set frequency for display shown below and depress LOCK. Measure period at U13C(10).	NOTE: frequency counter still uses external oscillator as time base.	Check Counter (U19 to U24), Storage Buffer (U7 to U12), and Display A1U4 to A1U9 associated with incorrect digit.
	Depress EXPAND x10 Display: 0.8 8 8 8 8 or 0.8 8 8 8 9 / 0.7 7 7 7 / .7 X X X X / .8 X X X X X Measured Period (µs): 8 8 8 8 . 8 or 8 8 8 8 . 9 / 7 7 7 7 . 7 / 7 X X X . X / 8 X X X . X		Check Counter (U19 to U24), Storage Buffer (U7 to U12), and Display (A1U4 to A1U9) associated with incorrect digit. If no signal is present or second digit from right is incorrect, also check U2A, U13C, and U28.
D.	**Overflow Detector (A1A2A1)**		
1	Connect 10.1 MHz, 1 Vrms signal to EXT COUNT input. Measure at U5B(8).	TTL high.	Check U4B, U5, and associated components.
		OVERFLOW light on.	Check Q18, A1A2A2DS1, and associated components.
2	Set oscillator to 9.9 MHz.	OVERFLOW light goes off.	Check U4B, U5, and associated components.
E.	**Flash Oscillator (A1A2A1)**		
1	Depress LOCK.	Display blinks at 2 Hz rate.	Check U3D(11) for TTL high (see Service Sheet 5). If high, check Q3, Q4, Q5, and associated components. If low, see Service Sheet 5: Lock Switching.
2	Release LOCK.	Blinking stops.	See Service Sheet 5: Lock Switching.
F.	**500 Hz Digit (A1)**		
1	Depress LOCK +500 Hz.	New least significant digit appears (5).	Check U3 and line to U3(1) should be low.

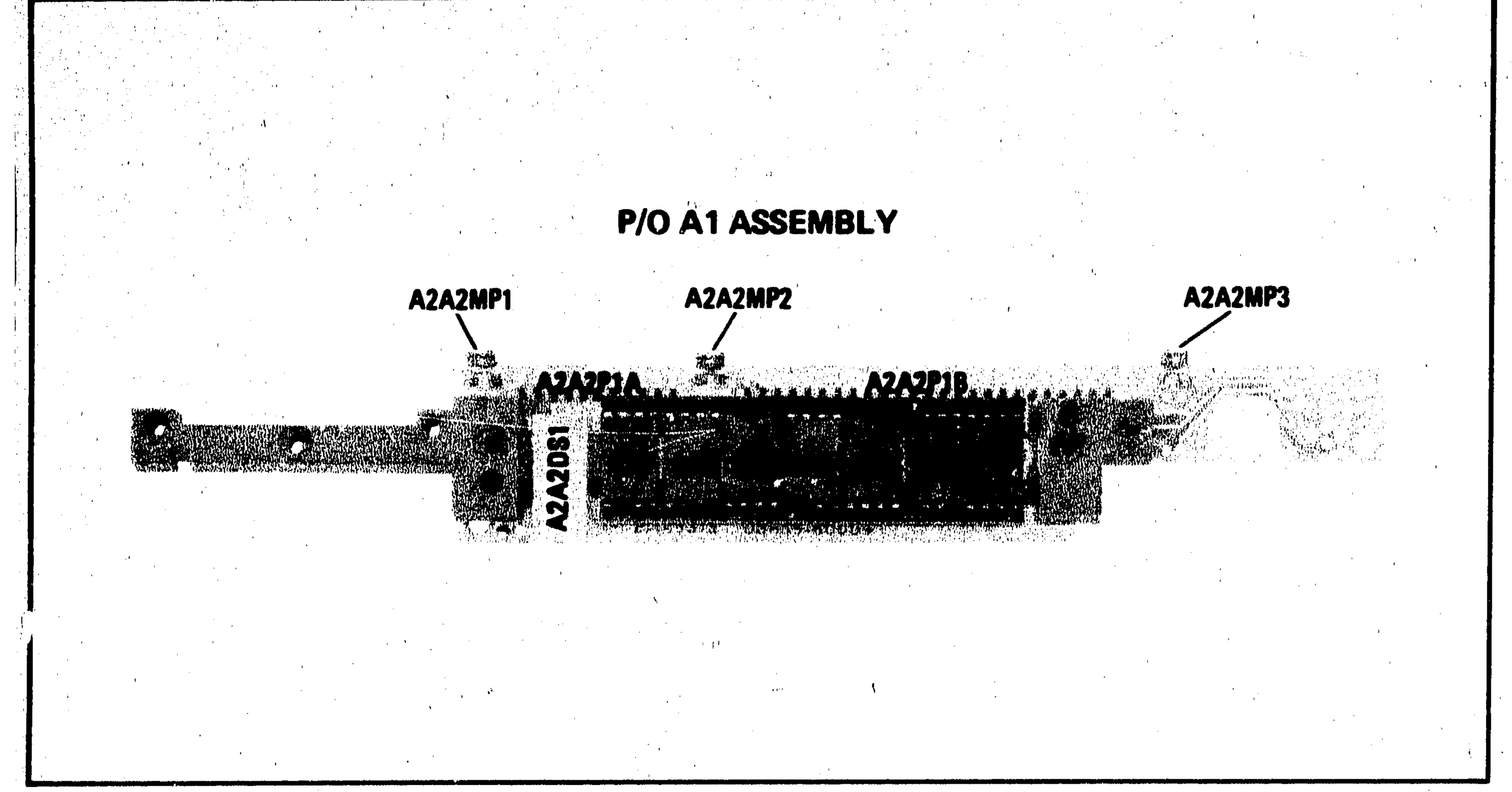


Figure 8-20. P/O A1 Counter/Lock Assembly (Display) Component Locations

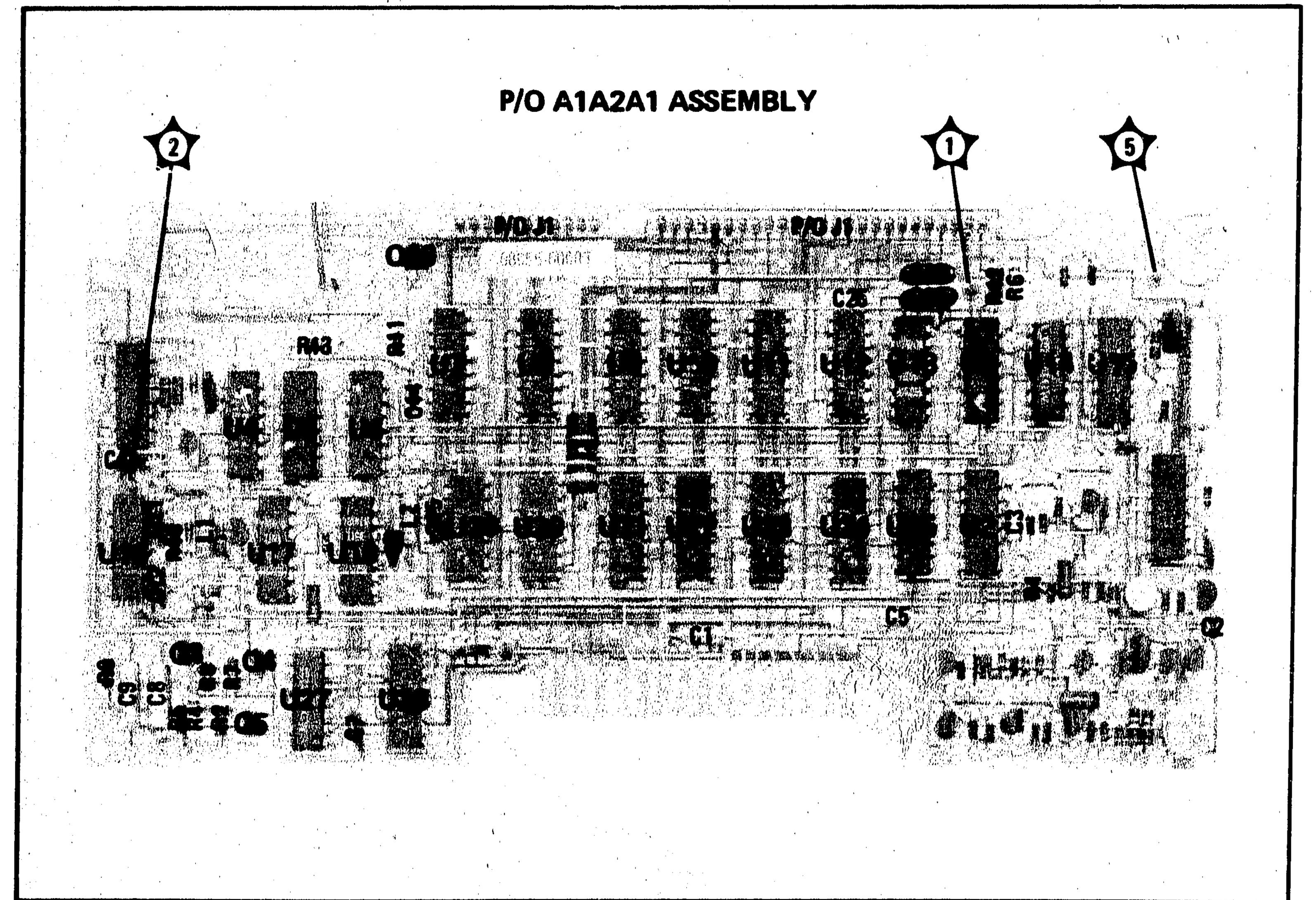
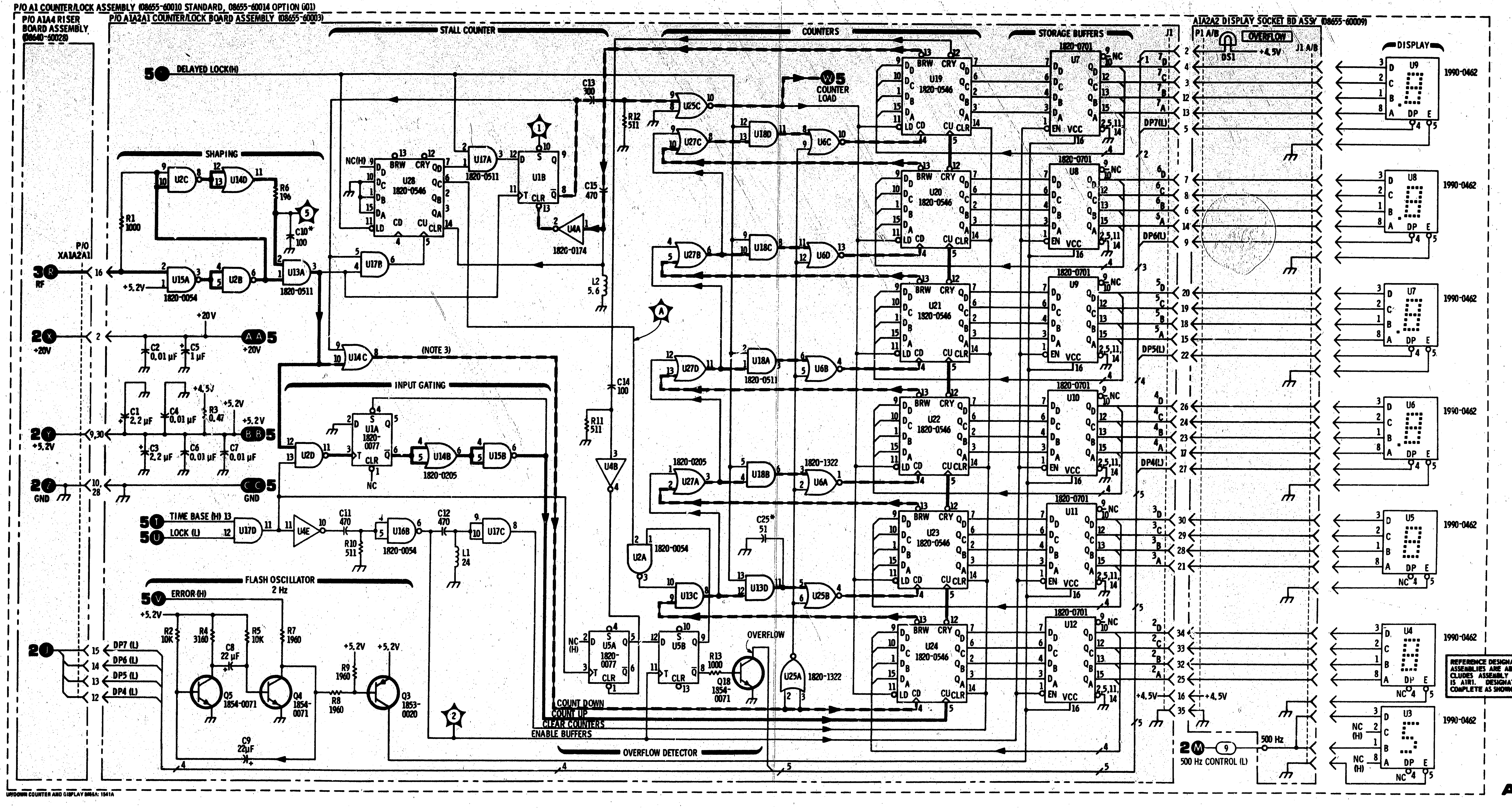


Figure 8-21. P/O A1A2A1 Counter/Lock Board Assembly (Up/Down Counter) Component Locations



NOTES

1. UNLESS OTHERWISE INDICATED:
   RESISTANCE IN OHMS;
   CAPACITANCE IN PICOFARADS;
   INDUCTANCE IN MICROHENRIES.
2. REFER TO FIGURE 8-10 FOR GENERAL SCHEMATIC DIAGRAM NOTES.
3. HEAVY DASHED LINE WITH ARROWS (——▶——) INDICATES COUNT DOWN/PHASE LOCK SIGNAL FLOW.

* SELECTED COMPONENT. AVERAGE VALUE SHOWN (SEE SECTION V).

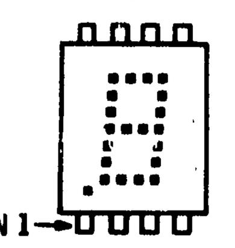
REFERENCE DESIGNATIONS

A1A2A1 ASSY	P/O A1 ASSY
C1-15,25 J1 L1,2 Q3-5,18 R1-13 TP1,2,5 U1,2,4-25, 27,28	U3-9 **A1A2A2 ASSY** DS1 J1 P1 **P/O A1A4 ASSY** XA1A2A1

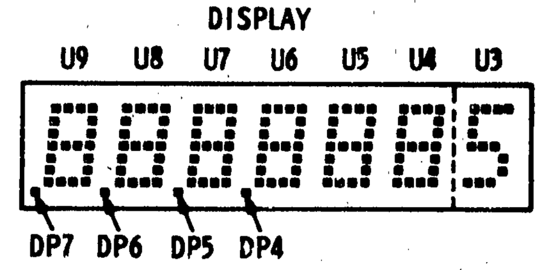
INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
A1A2A1U1,2, 4-6,13-18,25,27	+5.2V - 14 GND - 7
A1A2A1U7-12, 19-24,28	+5.2V - 16 GND - 8
A1U3-9	+5.2V - 7 GND - 6

A1U3 THRU U9 TOP VIEW



DISPLAY



REFERENCE DESIGNATIONS WITHIN OUTLINED (— — —) ASSEMBLIES ARE ABBREVIATED. FULL DESIGNATION INCLUDES ASSEMBLY NUMBER; e.g., R1 OF ASSEMBLY A1 IS A1R1. DESIGNATIONS OF OTHER COMPONENTS ARE COMPLETE AS SHOWN.

4
A1,A1A2A1,A1A2A2

Figure 8-22. Up/Down Counter and Display Schematic Diagram

SERVICE SHEET 4A

PRINCIPLES OF OPERATION

General

The counter has two modes of operation:

1) Count: The counter counts the input frequency (count-up mode).

2) Phase Lock: The counter finishes the current count sequence, stores the count, then enters phase lock counting down from the stored count to zero in a free-running mode (count-down).

Counter Operation — Count-Up Mode (see Figure 8-23)

When the SYNCHRONIZE LOCK switches are out, the LOCK line is high. When the TIME BASE line is high, decade counters U19 through U24 count the input pulses. When TIME BASE goes low, the count is inhibited, the counter outputs are transferred to the outputs of Storage Buffers U7 through U12. These in turn drive the numeric displays A1U4 through U9. The Storage Buffer outputs are latched, and the counters are cleared. When TIME BASE goes high, the count begins again.

Shaping and Input Gating

Gates U15A, U2B, U2C, U14D, and U13A shape the input waveform into pulses of about 30 nanoseconds duration. The circuit uses gate delays and positive feedback to shape the pulses. NAND gate U2D blocks the input to the counter when TIME BASE is low. D flip-flop U1A and gates U14B and U15B also shape the input pulses and further assure that the pulse is either of full duration or is absent in the event that TIME BASE goes low while an input pulse is high.

The output of gate U17C is normally low, and the output of gate U16B is normally high (the resistor R10 and inductor L1 hold the inputs low). When the TIME BASE goes low, the output of inverter U4E goes high. The output of U16B goes low until resistor R10 discharges capacitor C11 and the output returns to a high. While U16B is low, the enable (EN) inputs of the storage buffers allow the data inputs to transfer to the outputs. When the output of U16B goes high, the output of U17C goes high until inductor L1 charges C12 and the output returns to a low. While U17C is high, the counters are cleared. When TIME BASE goes high, the outputs of U16B and U17C remain unchanged.

Overflow Detector

The overflow detector lights the OVERFLOW lamp whenever a carry is generated by counter U19, in which case the count has exceeded the number of digits available in the display. The output of inverter U4B is normally high. Counter U19 generates a low at the carry (CRY) output on the count of nine and the output of U4B remains high. At the count of ten, the carry output of U19 returns high, output of U4B goes low until resistor R11 discharges capacitor C14 and the output returns to a high. While U4B is low, D flip-flop U5A clears. Shortly after TIME BASE goes low, the output of U16B goes high and toggles D flip-flop U5B. If a low was present at the D input, the $\overline{Q}$ output goes high, turns on transistor Q18 and lights the OVERFLOW lamp; otherwise $\overline{Q}$ remains low. When the TIME BASE goes high, the Q output of U5A goes (or remains) high, and remains so until another overflow carry is generated. Therefore, the counter must generate an overflow carry each time base period to keep the OVERFLOW lamp lighted.

Counter Operation — Phase Lock, Count-Down Mode (see Figure 8-24)

When either Lock switch is depressed, the count just prior to acquisition of phase lock is transferred to Storage Buffers U7 through U12. Then the buffers are latched (i.e., last count is stored). The decade counters U19 to U24 are cleared and preset from the Storage Buffers. Then they count the input pulses, counting down from the number transferred from the buffers.

In brief, the counter counts down to zero, then to 999,999. It is then preset to the stored count where it remains for four more clock pulses (as counted in Stall Counter). A count pulse into the second counter then subtracts ten from the preset count. Finally, when a total of nine pulses has been counted by the Stall Counter, the main counter starts counting down towards zero. The stall of nine counts gives the main counters adequate time to preset. The nine count delay plus the count to one below zero (i.e., to 999,999) is compensated for by subtracting ten from the main counter.

The circuit implementation of the sequence is as follows: When the count reaches 000,000, the borrow (BRW) output of U19 goes low. The count proceeds to 999,999 at which time the borrow

output goes high. Normally, the input to inverter U4A is held low by inductor L2. The high at the borrow output of U19 is coupled through capacitor C15 to the inverter and also to the clear (CLR) input of the Stall Counter U28. The inputs are held high long enough to clear U28 and flip-flop U1B. The $\overline{Q}$ output of U1B goes high and is coupled through C13 causing the output of U25C to go low (Counter Load). When the Counter Load line is low the number stored in the buffers is loaded into the counters preset). $\overline{Q}$ of U1B also inhibits the input to the main counter by means of OR gate U14C and enables the Stall Counter by means of AND gate U17B. When counter U28 reaches a count of four, output Q_C goes high and the output of NAND gate U2A goes low. The borrow output of counter U24 is high because the count down (CD) input is held high by U14C. The low from the output of U2A causes a low at the output of U13C and also U13D. Since the output of U14C is high, the output of NOR gate U25A is low. The low from U13D causes a high at the output of NOR gate U25B and clocks the count down (CD) input of U23 once. If U23 is at a zero count, its borrow output clocks counter U22. If U22 is at zero, it clocks counter U21, etc. When Stall Counter U28 reaches the count of eight, output Q_D goes high and causes a high on the D input of flip-flop U1B. The next clock causes the $\overline{Q}$ output of U1B to go low which inhibits the clock to the Stall Counter and enables the clock to the main counter. The main counter then counts down with each input pulse.

In the normal count down mode, decade counters U19 to U24 form a synchronous counter. OR gates U27A to U27C and AND gate U13C have high outputs unless all previous counters are at the zero count. When any of the OR gates (or AND gate U13C) are low, the output of the following NOR gate (U5A to U5D or U25B) goes high on the next clock input. Thus each counter changes count only at the occurrence of a clock input and only if all previous counters are zero (their borrows having rippled through to enable it).

Counter Operation — Transition from Counter Mode to Phase Lock Mode (A1A2A1)

When either LOCK switch is depressed (In), the counter sequences as follows: Counters U19 to U24 continue counting up until TIME BASE goes low. Stall Counter U28 has been preset to the count of eight, Storage Buffers U7 through U12 are loaded with the outputs of the counters and then latched; then the counters are cleared and the input to the main counter is inhibited while the input to the Stall Counter is enabled. The lock mode is now entered with the DELAYED LOCK line high, and the Q_D output of Stall Counter U28 is high. The D input of U1B is high and the next clock input toggles the $\overline{Q}$ output to a low. The clock to the main counter is then enabled and that to the Stall Counter disabled. The next input pulse sends the main counter to 999,999 since it was previously cleared to zero. The counter now sequences in the normal phase lock mode.

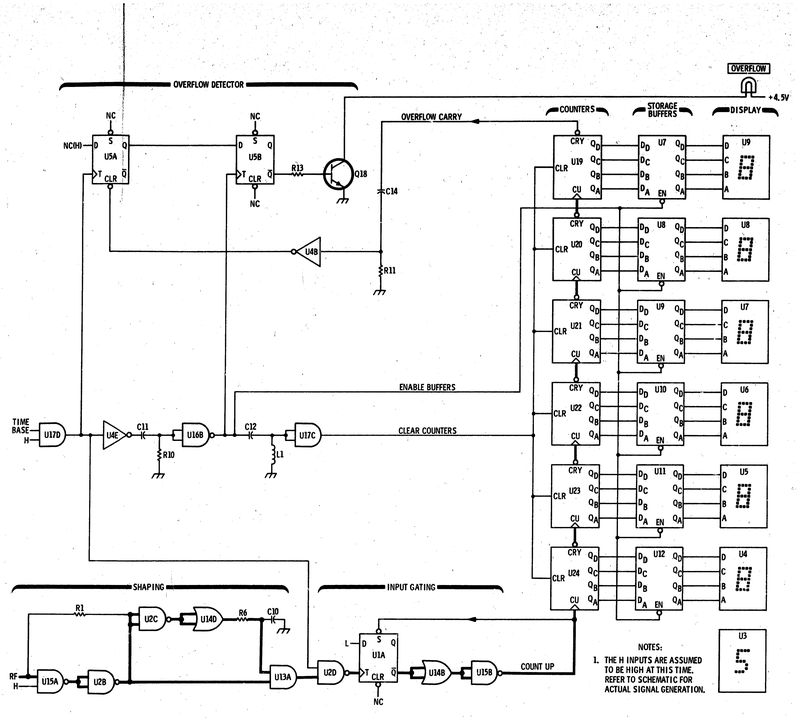


Figure 8-23. Up Counter (Counter Mode) S..nplified Diagram

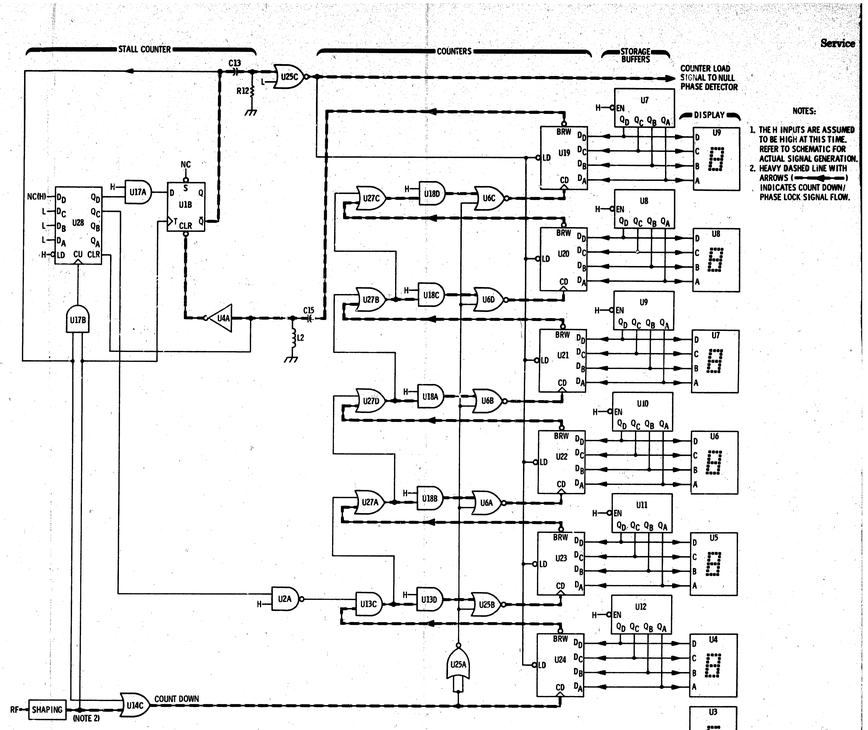


Figure 8-24. Down Counter (Phase Lock Mode) Simplified Diagram

SERVICE SHEET 5

PRINCIPLES OF OPERATION

Initiation of Phase Lock (A1A2A1)

The lock mode is entered as follows: Cross-coupled NAND gates U3A and U3B form an RS flip-flop. The output of U3A is low in the count mode and goes high after either LOCK switch is depressed and TIME BASE goes low. It remains high until the switches are unlocked. Transistor Q1 and diodes CR1 and CR2 form an OR gate, with TIME BASE and LOCK switches as inputs.

When the phase lock error exceeds a predetermined limit, an error condition exists and a low appears at the input to NAND gate U16A and at the input to NAND gate U3D of the cross coupled pair formed by U3C and U3D (RS flip-flop). The output of U3D goes high and turns on the Flash Oscillator (Service Sheet 4). The output of U3C is normally high, but goes low when an error exists (if U3A is high). The output of NAND gate U16C is low when phase lock exists. This is true when the output of U3A is high (i.e., either LOCK switch has been depressed and after TIME BASE has gone low) and the output of U3C is high (i.e., in addition no error exists). The output of U16C is delayed by the resistor-capacitor network of R47 and C21 and inverted by U4D which enables the Stall Counter and the main counter. When excessive error occurs, the output of U16C goes high and the counter breaks phase lock (reverts to count mode). Phase lock is re-established when the LOCK switches are released and depressed again. As an aid to troubleshooting, TP4 can be grounded to prevent the error condition from reaching U3D.

Phase Detector Circuit (A1A2A1)

A phase error is sensed in the Null Phase Detector by detecting the difference in time of occurrence of COUNTER LOAD (the 999,999 count of the counter; see Service Sheet 4) and the TIME BASE signal. D flip-flops U26A and U26B and NAND gate U15C form the phase detector. When phase locked, both set (S) inputs are high. Between the low occurrences of COUNTER LOAD and TIME BASE, the Q outputs of both U26A and U26B are low. If COUNTER LOAD goes high first, the Q output of U26B goes high first. When TIME BASE goes high, the Q output of U26A goes high. Both inputs of NAND gate U15C are now high so the output goes low, and after a slight delay through resistor-capacitor network R14 and C16 and OR gate U14A both flip-flops are cleared. Since U26B was triggered first, its $\overline{Q}$ output remained low longer than the $\overline{Q}$ output of U26A. If a high on TIME BASE had occurred first, the opposite would have been true. If both occur simultaneously, both outputs remain high for an equal duration.

The $\overline{Q}$ output pulses of U26A and U26B are increased in duration by a Pulse Width Stretcher and then drive Current Sources which charge and discharge storage capacitor C20. When the $\overline{Q}$ output of U26B goes low it turns on transistor switch Q8. Capacitor C18 is at 10V when Q8 is off because the non-inverting input of amplifier U29A is at 10V; the output of U29A is also at 10V since, with Q8 off, no current flows through R27 and R29. When Q8 goes on, C18 rapidly discharges through Q8. The output of U29A goes high to about 20V and remains at that voltage until Q8 switches off and C18 charges slowly to about 10V. Current source Q7 is on when the output of U29A goes high. In a similar manner, amplifier U29B goes high and turns on current source Q12 when the $\overline{Q}$ output of U26A goes low. Current source Q7 charges capacitor C20 and Q12 discharges it. Any phase difference from the phase detector results in a net charge or discharge (i.e., an increase or decrease in voltage) of C20. FET Q6 is a high impedance buffer amplifier which drives buffer Q11. Q11 drives the Sample and Hold filter. In the normal count mode U26A and U26B are both set and cleared, i.e., Q and $\overline{Q}$ are simultaneously high, the current sources Q15 and Q14 are switched on to bias C20 at a nominal mid-range voltage.

Error Detector (A1A2A1)

If the phase lock tune voltage from Q11 is too high or too low, the limit of the lock range is exceeded. The excessive error is sensed by transistors Q2 and Q15. The emitter of Q2 is held at a positive dc reference by VR1 and R26 to bias Q2 on. If the base of Q15 is too low, Q15 turns off; its collector goes high and turns off Q2. If the base of Q15 is high Q15 saturates. At this point, an increase in base voltage will force an increase in collector voltage (collector tracks base) and ultimately turn Q2 off. When Q2 turns off, a low exists at pin 2 of U16A. This low represents an excessive error causing the Flash Oscillator to trigger and the counter to break phase lock (revert to count mode).

SERVICE SHEET 5 (Cont'd)

Low-Pass Filtering (A1A3)

FETs Q1 and Q2 and capacitor C36 form a sample-and-hold circuit which filters the phase lock tune voltage. Q2 is a switch that is controlled by Q3. If Q3 is off, the gate-to-source junction of Q2 is biased at 0V since no current flows through R26. This biases Q2 on and allows C36 to change to the voltage present at the emitter of A1A2A1Q11. If Q3 is on, the gate-to-source junction of Q2 is reverse-biased beyond its pinch-off level (since the source of Q2 is usually a few volts positive) and Q2 is cut off. Because of the high impedance of the gate of Q1 and the cut-off drain of Q2, C36 maintains its charge between sample intervals of Q2. Q1 acts as a buffer amplifier. L10, C38, and C39 form a low-pass RFI filter.

The sample signal comes from the Time Base line. The time base is delayed by U4A to allow adequate time for the Counter Load to trigger the Null Phase Detector if that event occurs after the time base rather than before. U4B is triggered by U4A (going high) and determines the sample-time of Q2. U4A and U4B are monostable multivibrators (one shots), the $\overline{Q}$ output goes low when triggered at the input and remains low for a period of time determined by the resistor-capacitor combination at the C and R/C inputs.

Phase Lock Driver (A4)

The Phase Lock Driver circuits adjust the level, sense, and gain of the tune signal from the phase lock circuits as needed for the particular external generator connected to the instrument. For the HP 8654B switches S7 and S9 route the signal through U4 which inverts the signal. C1 adds filtering to the line. R2 sets the dc offset to zero when unlocked. For the 8654A the signal is amplified but not inverted. R8, C2, and C3 add filtering to the line. For other external signal generators a suitable driver may be connected between pins 8 and 4 (or 12) of J3 and S9 set to OTHER.

TROUBLESHOOTING

DESCRIPTION:

The phase detector circuits are troubleshot by observing the tune line from the detector as the two inputs are separately triggered (to simulate a phase error increase and decrease). The other circuits are checked by checking the circuit outputs under various input conditions.

TEST EQUIPMENT:

Multimeter . . . . . HP 34702A/34740A
Oscilloscope . . . . . HP 1820C/1801A/182C
Voltage Divider Probe . . . . . HP 10004D

PROCEDURE:

1. Remove instrument's front panel and top cover.
2. Remove counter top cover and A1A2 Counter/Display Assembly with riser board. Remove riser board and return A1A2 Assembly to counter on an extender board (see Service Sheet A).
3. Set controls as follows: (see Figure 8-11):

POWER . . . . . ON(In)
SYNCHRONIZE COUNT . . . . . In
LOCK . . . . . Out
LOCK +500 Hz . . . . . Out
EXPAND x10 . . . . . Out
TIME BASE (rear panel except Option 001) . . . . . INT

4. Go to the section in Table 8-5 which describes troubleshooting for the suspected area. Start at the beginning of the section and follow the steps in sequence. Before beginning another section, return controls to positions described in step 3.

Table 8-5. Phase Lock Circuits Troubleshooting (1 of 2)

Step	Instructions	Normal Indication	If Indication Abnormal
A.	**Lock Switching (A1A2A1)**		
1	Ground TP4. Short A1A3TP3 (see Service Sheet 2) to +4.5V (available at R3, see Service Sheet 4). Depress LOCK. Measure at Q1(e).	Negative going pulses, >2 Vp-p, 156.25 Hz, 0.5 to 1.5 μs wide. Note: trace will be very faint.	Check Q1, CR1, CR2, and associated components. The anode of CR2 should be <0.2 Vdc.
2	Measure at U16C(8).	TTL low.	Check U3 and U16C.
3	Measure at U4D(8) and U4F(12).	TTL high.	Check U4D, U4F, R47, and C21.
B.	**Phase Detector Circuits (A1A2A1)**		
1	Switch TIME BASE (rear panel) to EXT or for Option 001, disconnect W8 (see Service Sheet 2). Measure at TP6.	10 to 12 Vdc. If correct go to step 7.	Continue with steps 2 to 6.
2	Measure at U26A(5), U26A(6), U26B(9) and U26B(8).	TTL high. NOTE: A simultaneous set and clear makes Q and $\overline{Q}$ high.	Check U14A, U15C, U15D, U26, and associated components. U15D(12) should be high. U15D(11), U14A(3), and U15C(8) should be low.
3	Measure at Q8(c) and Q9(c).	9.7 to 10.3 Vdc.	Check Q8, Q9, U29, and associated components. U29A(3) should be 9.7 to 10.3 Vdc.
4	Measure at U29A(1) and U29B(7).	9.7 to 10.3 Vdc.	Check U29 and associated components.
5	Measure at Q6(g).	9.7 to 10.3 Vdc.	Check Q6, Q7, Q10, Q12, Q13, Q14, and associated components. Q13 and Q14 should be saturated (i.e., V_{CE} <0.2 Vdc).
6	Measure at Q11(b).	0.5 to 2V greater than Q6(g).	Check Q6. Otherwise check Q11.
7	Ground TP4. Depress LOCK. Set TIME BASE (rear panel) to INT then back to EXT (or for Option 001, reconnect and disconnect W8). This sets U16C(8) to low. Momentarily ground U14A(1) (clears U26). Measure at TP6. NOTE: during steps 8 to 11, transients may cause lock to break. If so, repeat this step.	4 to 17 Vdc and stable.	Check U26, U29, Q8, Q9, and associated components. U15D(11) should be high. U26A(5) and U26B(9) should be low.
8	Momentarily ground U26B(11) (clocks U26B). Measure at TP6.	Voltage rises to 15 to 18 Vdc.	Check U26B, U29A, Q7, Q8, and associated components. Q8(c) should be 4.5 Vdc. U29A(1) should be 20 Vdc. Q13(c) and Q14(c) should be same voltage as Q6(g).
9	Momentarily ground U14A(1) (clears U26). Measure at TP6.	4 to 17 Vdc and stable.	Check U26B, Q14, and associated components. U26B(9) should be low.
10	Momentarily ground U26A(3) (clocks U26A). Measure at TP6.	Voltage drops to 4 to 7 Vdc.	Check U26A, U29B, Q9, Q12, and associated components. Q9(c) should be 4.5 Vdc. U29B(7) should be 20 Vdc.
11	Momentarily ground U14A(1) (clears U26). Measure at TP6.	4 to 17 Vdc and stable.	Check U26A, Q13, and associated components. U26A(5) should be low.

Table 8-5. Phase Lock Circuits Troubleshooting (2 of 2)

Step	Instructions	Normal Indication	If Indication Abnormal
C.	**Error Detector**		
1	Ground TP4. Depress LOCK. Set TIME BASE (rear panel) to EXT or for Option 001, disconnect W8 (see Service Sheet 2). Momentarily ground U26A(3). Measure at U16A(3).	TTL high.	Check Q2, Q15, U16A, and associated components. U16A(2) should be low. TP6 should be 4 to 7 Vdc.
2	Momentarily ground U14A(1) then momentarily ground U26B(11). Measure at U16A(3).	TTL high. NOTE: a wait of a few seconds may be necessary.	Check Q2, Q15, U16A, and associated components. U16A(2) should be low. TP6 should be 15 to 18 Vdc.
3	Remove ground from TP4. Measure at U3D(11).	TTL high. NOTE: a wait of a few seconds may be necessary.	Check U3D and U16D.
4	Release LOCK. Measure at U16A(3).	TTL low.	Check Q2, Q15, U16A, and associated components. U16A(2) should be high.
5	Measure at U3D(11).	TTL low.	Check U3, Q1 and associated components.
D.	**Low-Pass Filtering (A1A3)**		
1	Measure at U4A(4).	TTL pulses (negative going), 16 to 26 ms wide.	Check U4A and associated components.
2	Measure at U4B(12).	Negative going TTL pulses, 1 to 5 ms wide.	Check U4B and associated components.
3	Ground Q3(b). Measure at Q2(s) and Q2(d).	Both voltages between 10 and 12 Vdc and within 20 mV of each other.	Check Q2, Q3, and associated components.
4	Monitor Q1(s) as ground is removed from Q3(b) and placed on Q3(c).	Voltage between 10.5 and 14 Vdc and remains constant for several seconds.	Check Q1, Q2, and associated components.
E.	**Phase Lock Driver (A4)**		
1	Connect TP5 to TP2 (see Service Sheet 6). Measure at TP6 with S7 and S9 set as follows:		
	S9 OTHER	0 Vdc.	Check S9.
	S7 8654B S9 8654	−2 to −4 Vdc.	Check U4 and associated components.
	S7 8654A S9 8654	9 to 11 Vdc.	Check U5 and associated components.
2	Remove short between TP5 and TP2. Measure at TP4.	9 to 13 Vdc.	Check line to TP4.
3	Measure at TP5.	0.0 ± 0.5 Vdc.	Check R1, R2, and R3. If only slightly out of range, perform Phase Lock Offset Adjustment in Section 5.

Counter/Lock Circuits (Simplified)
SERVICE SHEET 4A

P/O A1A2A1 ASSEMBLY

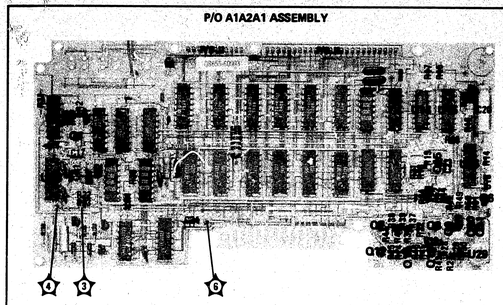


Figure 8-25. P/O A1A2A1 Counter/Lock Board Assembly (Phase Lock Circuit) Component Locations

P/O A1A3 ASSEMBLY

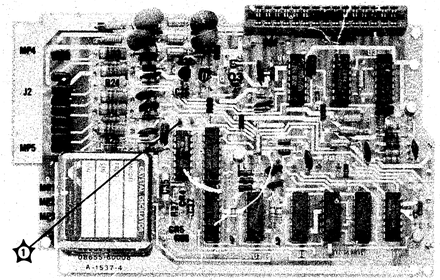


Figure 8-26. P/O A1A3 Time Base Board Assembly (Low-Pass Filter) Component Locations

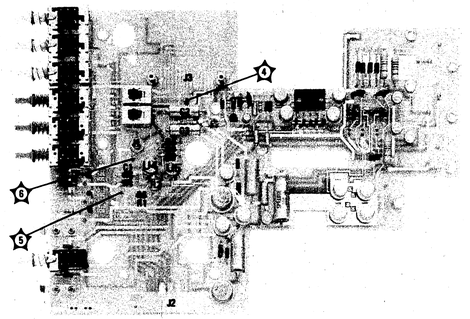


Figure 8-27. P/O A4 Power Supply/Control Board Assembly (Phase Lock Driver) Component Locations

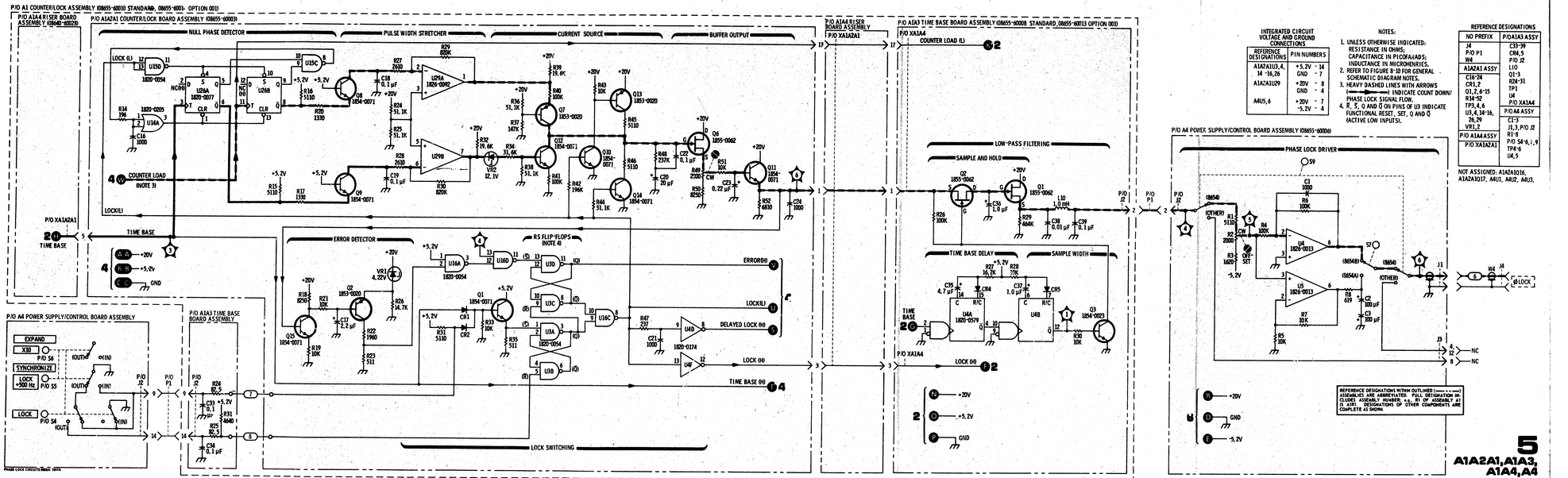


Figure 8-28. Phase Lock Circuits Schematic Diagram

5
A1A2A1, A1A3, A1A4, A4

SERVICE SHEET 6

PRINCIPLES OF OPERATION

Regulators (A4)

The instrument has three similar dc power supplies: +20V, +5.2V, and −5.2V. The +5.2V and −5.2V supplies are switched off with the POWER switch set to STANDBY. The +20V supply remains on. The regulator inputs are fused. The regulator IC's have a reference, series-pass transistor, and built-in over-current protection. The supplies are adjusted by R18, R20, and R22. CR16, CR17, and CR18 protect the supplies against shorts to a supply of opposite polarity. The crowbars for the +5.2V and −5.2V supplies protect against excessively high output voltages by shorting the supplies when the respective break-down diodes (VR2 or VR3) conduct. Finally, each supply has an LED to indicate that it is working — if the LED is off, there is a fault in the supply or a short on the supply line.

Fan Motor (A3) and Fan Driver (A4)

Fan Motor A3B1 is a brushless, dc motor comprising a cylindrical, permanent magnet rotor and a four-section stator winding. The stator windings are energized sequentially by driver transistors Q3 through Q6 which are driven by two Hall generators. The Hall generators are located on the stator, 90° apart. In the presence of a magnetic field, each Hall generator produces two out-of-phase voltages at its output terminals. The magnitude of the voltage is proportional to the strength of the field and the amount of bias current. The phase is determined by the polarity of the field. The Hall generators sense the position of the rotor and turn on the appropriate driver transistor.

A back-emf proportional to rotor speed is induced in the unenergized stator windings. Diodes CR3 thru CR6 rectify this emf and charge C4 to a negative voltage. Current source Q7 discharges C4 at a constant rate. The voltage across C4 plus the constant voltage drop across R11 is the base voltage of Q8. If rotor speed decreases, the voltage across C4 becomes less negative, the base of Q8 becomes more positive and Q8 increases the bias on the Hall generators. The driver transistors turn on harder and the rotor speed increases.

SERVICE SHEET 6 (Cont'd)

TROUBLESHOOTING

DESCRIPTION:

The three power supplies are troubleshot by checking inputs and outputs and load resistance. The fan driver circuits are first checked with the motor interconnect removed, then the action of the drivers is checked with the motor connected.

TEST EQUIPMENT:

Multimeter ..... HP 34702A/34740A
Oscilloscope ..... HP 1820C/1801A/182C

PROCEDURE:

1. Remove instrument bottom cover.
2. Set POWER switch to ON (In).
3. Go to the section in Table 8-6 which describes troubleshooting for the suspected area. Start at the beginning of the section and follow the steps in sequence.

SERVICE SHEET 6 (Cont'd)

Table 8-6. Power Supply and Fan Motor Circuits Troubleshooting

Step	Instructions	Normal Indication	If Indication Abnormal
A.	**Power Supplies (A4)**		
1	Set POWER to STANDBY. Measure at XA2(2).	29 to 39 Vdc.	Check line fuse, T1, POWER switch, rectifiers, and filter capacitors associated with faulty supply.
2	Measure at XA2(4).	12 to 16 Vdc.	
3	Measure at XA2(5)	−12 to −16 Vdc.	
4	Set POWER to ON. Measure at XA2(2).	29 to 39 Vdc, <0.4 Vp-p ripple.	
5	Measure at XA2(4).	10 to 14 Vdc, <2 Vp-p ripple.	
6	Measure at XA2(5).	−10 to −14 Vdc, <3 Vp-p ripple.	
7	Measure at TP1.	20.1 to 20.3 Vdc, <10 mVp-p ripple.	Check fuse, regulator and crowbar associated with faulty supply (also see steps 10 to 12).
8	Measure at TP2.	5.1 to 5.3 Vdc, <10 mVp-p ripple.	
9	Measure at TP3.	−5.1 to −5.3 Vdc, < 10 mVp-p ripple.	
10	Remove line cord. Measure resistance from TP1 to ground.	>300 Ω.	Probable shorted load. Remove A1 Counter Assembly to check if short is in counter or on A4 Power Supply/Control Board Assembly (see Service Sheet 8)
11	Measure resistance from TP2 to ground.	>40 Ω.	
12	Measure resistance from TP3 to ground.	>30 Ω.	
B.	**Fan Circuits (A4)**		
1	Remove fan motor interconnect cable W6. Measure at the following points:		
	Q7(b)	−5 to −7 Vdc.	Check Q7 and associated components.
	Q7(e)	0.7V more positive than Q7(b).	Check Q7 and associated components.
	Q8(e)	−10 to −16 Vdc.	Check −10V input to −5.2V regulator.
	Q8(b)	0.7V more positive than Q8(e).	Check Q7, Q8, and associated components.
	Q8(c)	Approximately the same as Q8(e).	Check Q8 and associated components.
	Q3(c), Q4(c), Q5(c), and Q6(c).	Approximately −0.1 Vdc.	Check Q3 to Q6 and CR3 to CR6.
2	Reconnect W6. Measure at Q3(c), Q4(c), Q5(c), and Q6(c).	Distorted sinewave, 12 to 13 Vp-p, approximately 20 ms period, and motor running.	If motor is not running, try cycling POWER switch on and off while manually repositioning the fan blade. If motor will not start, check A3B1, W6, and Q8 (see note). If motor runs slowly check Q3 to Q6 (then see note). If motor runs too fast, check Q8. NOTE: Q8 is easily checked by placing a ≈200 Ω in parallel with collector-emitter. The motor should speed up. This indicates that Q8 is defective if Q3 to Q7 are known good.

Phase Lock Circuits
A1A2A1, A1A3, A1A4, A4
◀ SERVICE SHEET 5

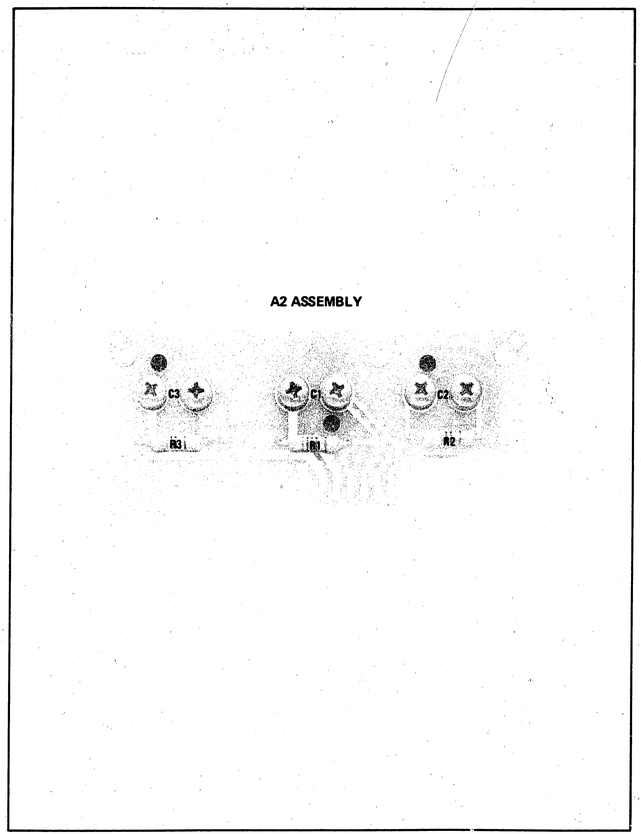


Figure 8-29. A2 Filter Board Assembly, Component Locations

P/O A4 ASSEMBLY

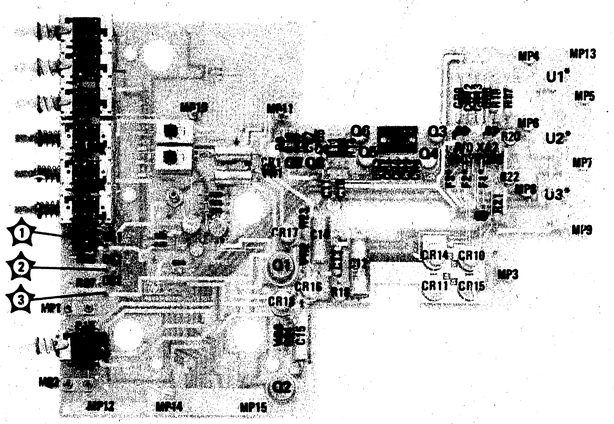
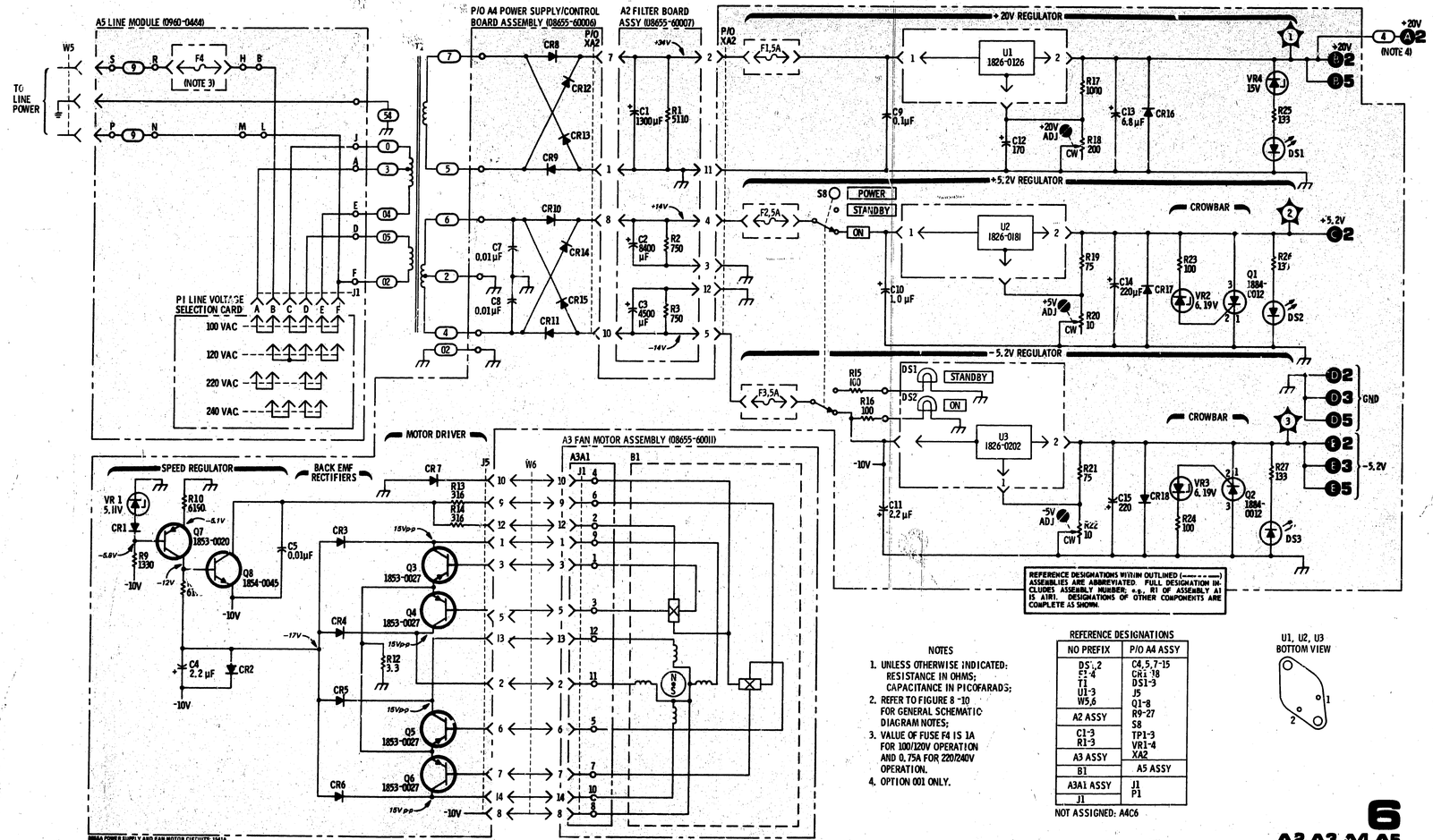


Figure 8-30. P/O A4 Power Supply/Control Board Assembly (Power Supplies) Component Locations



NOTES

1. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS; CAPACITANCE IN PICOFARADS;
2. REFER TO FIGURE 8-10 FOR GENERAL SCHEMATIC DIAGRAM NOTES;
3. VALUE OF FUSE F4 IS 1A FOR 100/120V OPERATION AND 0.75A FOR 220/240V OPERATION.
4. OPTION 001 ONLY.

REFERENCE DESIGNATIONS

NO PREFIX	P/O A4 ASSY
DS1,2 FT-4 T1 U1-3 W5,6	C4,5,7-15 CR1-18 DS1-3 J5 Q1-8 R9-27
A2 ASSY	S8
C1-3 R1-3	TP1-3 VR1-4 XA2
A3 ASSY	A5 ASSY
B1	
A3A1 ASSY	J1
J1	P1

NOT ASSIGNED: A4C6

U1, U2, U3 BOTTOM VIEW

Figure 8-31. Power Supply and Fan Motor Circuits Schematic Diagram

SERVICE SHEET A

General Information

Removal and installation procedures presented here do not require removal of the Counter/Lock casting from the instrument. However, if such removal is necessary, see procedure on Service Sheet B.

CAUTION

While working with or around semi-rigid coaxial cables, do not bend the cables more than necessary. Do not torque RF connectors more than 5 inch-pounds.

After completing any repairs (or troubleshooting that involved component changes) and before completing reassembly, perform the related tests and adjustments listed in Table 5-2. Generally, the power supply levels should be checked as shown in Section 5, and overall troubleshooting performed as shown at the beginning of this section. The RF Leakage Test in Section 4 should be performed after any disassembly of the Counter/Lock casting or RF interconnect cables.

Table 8-7, Counter/Lock Assembly Legend, is a cross reference for items in the exploded view and their reference designations.

Counter Top Cover Removal and Installation

To remove the Counter Top Cover (18), remove the following parts.

a. Time base calibration cover plate (2): two pan-head screws (with lockwashers) (1).

b. One pan-head screw (with lockwasher) on front of casting near display window (same as item 1).

c. Eight pan-head screws (with lockwashers) on top of cover [four short screws (16) in corners and four long screws (17) on sides].

Before installing Counter Top Cover, ensure the red filter (5) is not covering OVERFLOW light pipe (6). Then position left-rear corner of top cover (air intake). Next lower front of cover completely over the LED shield (4). Return all listed parts in reverse order.

A1A2 Counter/Display Assembly Removal and Installation

To remove Counter/Display Assembly (top board) (21), remove the following parts.

a. Counter top cover (18).

b. Two pan-head screws (with lockwashers) (14).

Lift top board and riser board (19) from connector on Time Base Board Assembly (48).

NOTE

At this point, the riser board can be removed and Counter/Display Assembly returned to counter on an extender board.

When installing Counter/Display Assembly ensure that LED shield (4) is carefully placed inside the bottom casting. Return all listed parts in reverse order.

A1A3 Time Base Board Assembly Removal and Installation

To remove the Time Base Board Assembly (48), remove the following parts.

a. Counter top cover (18).

b. A1A2 Counter/Display Assembly (21).

c. Five wires at feedthru filters.

d. One pan-head screw (with lockwasher) (45) in front-right corner of board.

e. Two 3/16 inch hexagonal board supports (50).

f. Push-on connector P3 (time base cable, underside of counter deck).

CAUTION

Do not remove the following three hex nuts unless semi-rigid coaxial cables W2 and W3 have been disconnected. To do so would place entire weight of Counter/Lock Assembly on the cables.

Loosen (do not remove) three 5/16 inch hex nuts (46) accessible through holes in A4 Power Supply/Control Board Assembly. Lift Time Base Board Assembly off 15-pin connector P1 and out-of-counter casting.

To install the Time Base Board Assembly, place board in counter casting on 15-pin connector P1. To avoid interference with the front panel, press counter casting to rear and tighten the three 5/16 inch hex nuts (46). Return all listed parts in reverse order.

A1A1 RF Scaler Board Assembly Removal and Installation

To remove the RF Scaler Board Assembly (30), remove the following parts.

a. Counter Top Cover (18).

b. A1A2 Counter/Display Assembly (21).

c. Counter input cover (23) and RFI strip (24): six pan-head screws (with lockwashers) (22).

d. Five wires at feedthru filters.

e. Two pan-head screws (with lockwashers) (27), two insulator bushings (28) and two nonmetalic washers (31) associated with A1U2 (29). (Do not remove A1U2.)

f. One pan-head screw (with lockwasher) (26) in front-left corner of board.

g. Two RF connectors on semi-rigid coaxial cables W2 and W3 (underside of instrument).

h. Two 1/4 inch hex nuts and lockwasher from RF connectors A1A1J1 and J2 (underside of instrument, same as items 43 and 44).

To install the RF Scaler Board Assembly, return all listed parts in reverse order.

LED Numeric Display IC's Removal and Installation

To remove LED Numeric Displays (52), remove the following parts.

a. Counter top cover (18).

b. A1A2 Counter/Display Assembly (21).

NOTE

Do not remove Display Socket Board Assembly (11) from Counter/Display Assembly (21).

c. LED shield (4): three flat-head screws (3).

After replacing an LED Numeric Display, return all listed parts in reverse order.

Table 8-7. Counter/Lock Assembly Legend

Item	Reference Designation	Item	Reference Designation
1	A1MP15	27	A1MP13
2	A1MP37	28	A1MP5
3	A1MP19	29	A1U2
4	A1MP36	30	A1A1
5	A1MP43	31	A1MP22
6	A1MP34	32	A1MP29
7	A1MP32	33	A1MP18
8	A1MP30	34	A1MP8
9	A1MP38	35	A1MP20
10	A1MP1	36	A1F1
11	A1A2A2	37	A1MP42
12	A1MP4	38	A1MP7
13	A1MP9	39	A1MP17
14	A1MP11	40	A1MP11
15	A1MP3	41	A1MP28
16	A1MP14	42	A1MP26
17	A1MP16	43	A1MP21
18	A1MP39	44	A1MP10
19	A1A4	45	A1MP11
20	A1MP35	46	MP49
21	A1A2	47	A1MP40
22	A1MP12	48	A1A3
23	A1MP31	49	A1MP18
24	A1MP27	50	A1MP33
25	A1MP41	51	A1MP1
26	A1MP11	52	A1U3-U9

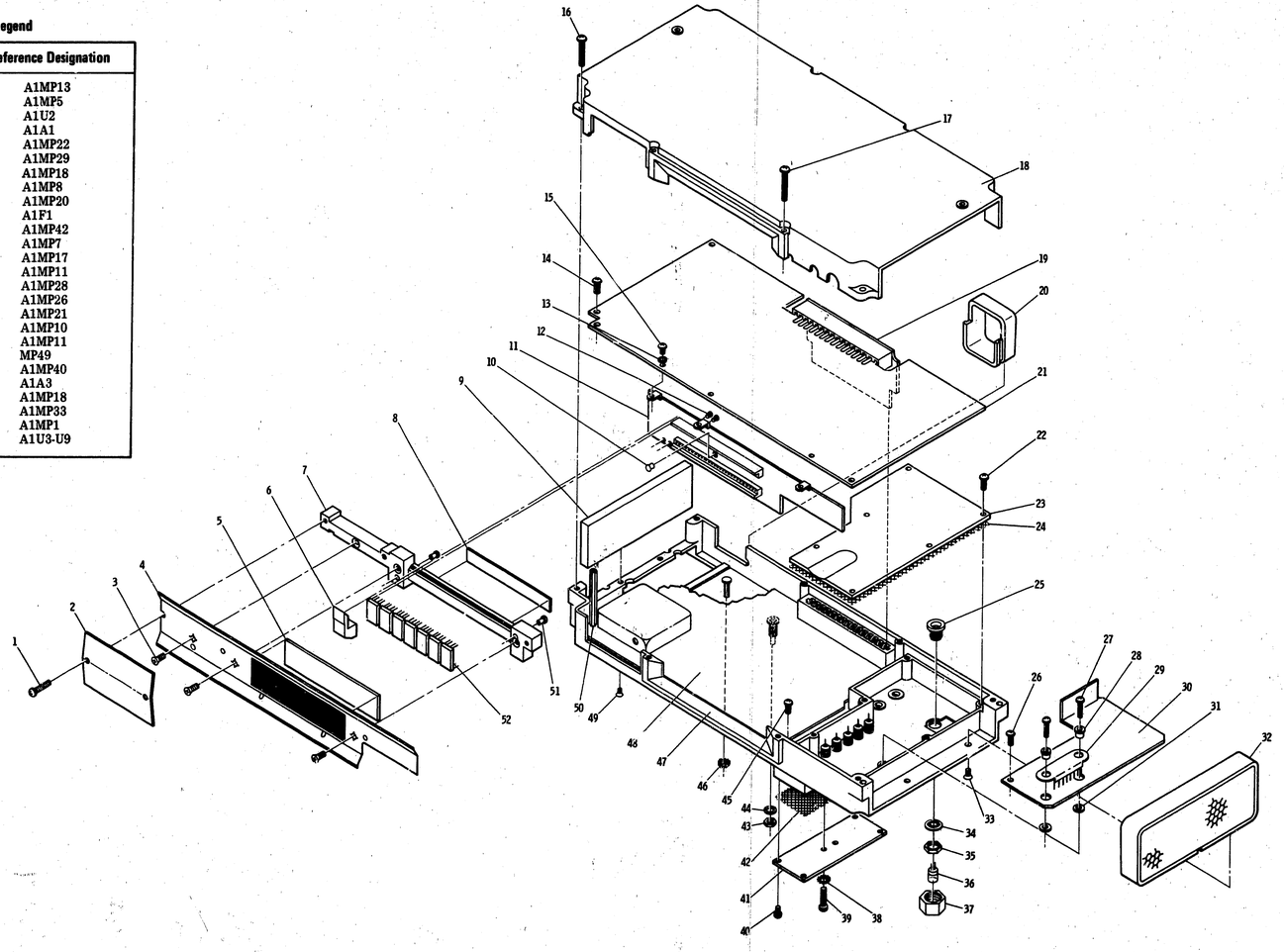


Figure 8-32. A1 Counter/Lock Assembly Illustrated Parts Breakdown

SERVICE SHEET B

General Information

CAUTION

While working with or around semi-rigid coaxial cables, do not bend the cables more than necessary. Do not torque RF connectors more than 5 inch-pounds.

Whenever DIP connectors on ribbon cables are removed from sockets, take care to prevent damage to connector pins.

After completing any repair (or troubleshooting that involved component changes) and before completing reassembly, perform the related tests and adjustments listed in Table 5-2. Generally, the power supply levels should be checked as shown in Section 5, and overall troubleshooting performed as shown at the beginning of this section. The RF Leakage Test in Section 4 should be performed after any disassembly of the Counter/Lock casting or RF Interconnect cables.

Front Panel

The front panel is secured by four flat-head screws on the side frames.

Top and Bottom Covers

The top cover is secured by four flat-head screws. The bottom cover is secured by two flat-head screws.

A1 Counter/Lock Assembly Removal and Installation

NOTE

Removal and Installation procedures for subassemblies within the counter casting are presented on Service Sheet A. Removal of entire Counter/Lock Assembly is not normally required to remove the subassemblies.

To remove the Counter/Lock Assembly, remove the following parts.

a. Front panel.

b. Top and bottom covers.

c. Two connectors on semi-rigid coaxial cables W2 and W3 at A1A1J1 and A1A1J2.

d. Push-on connector P3 (time base cable).

CAUTION

Do not remove the following three hex nuts unless semi-rigid coaxial cables have been disconnected. To do so would place entire weight of the Counter/Lock Assembly on the cables.

e. Three 5/16 inch hex nuts (with lockwashers) accessible through holes in Power Supply/Control Board Assembly.

Lift casting out of instrument. Remove 15-pin connector P1.

To install the Counter/Lock Assembly, install 15-pin connector P1. Place counter in instrument. To avoid interference with the front panel, press counter casting to rear before tightening the 5/16 inch hex nuts (step e). Return all listed parts in reverse order.

A2 Filter Board Assembly Removal and Installation

To remove the Filter Board Assembly, remove the following parts.

a. Top cover.

b. Two pan-head screws (with lockwashers) on filter board support bracket MP17. Lift assembly out of printed circuit board connector on Power Supply/Control Board Assembly.

To install the Filter Board Assembly, return all listed parts in reverse order.

A3 Fan Motor Assembly Removal and Installation

To remove the Fan Motor Assembly, remove the following parts.

a. Top and bottom covers.

b. Left-side cover (fan intake): six flat-head screws.

c. Blower housing MP10: two pan-head screws (with lockwashers) and one 5/16 inch hex nut (with lockwasher) on blower support bracket MP11.

d. Blower wheel MP12: one allen setscrew.

e. DIP connector on ribbon cable W6 at A3A1J1.

f. Three flat-head screws on blower support bracket MP11.

Carefully remove Fan Motor Assembly from the support bracket.

To install the Fan Motor Assembly return all listed parts in reverse order. Be careful not to apply excessive pressure to motor shaft. When replacing blower wheel, position it on shaft so that it does not rub against support bracket.

A4 Power Supply/Control Board Assembly Removal and Installation

To remove the Power Supply/Control Board Assembly, remove the following parts.

a. Front panel.

b. Top and bottom covers.

c. A2 Filter Board Assembly.

d. Six wires from transformer T1 and chassis.

e. Push-on connector P2 (yellow wire from rear panel Time Base switch: standard instruments only).

f. Three power supply regulator IC's: two large pan-head screws each (with lockwashers).

g. Push-on connector P3 (time base cable).

h. Coaxial cable W4 at A4J1 (ϕ Lock cable).

i. Semi-rigid coaxial cable W2 at A1A1J1.

J. DIP connector on ribbon cable W6 at A3A1J1.

k. Five pan-head screws (with lockwashers).

Lift Power Supply/Control Board Assembly from instrument being careful not to bend semi-rigid coaxial cable more than necessary. Remove 15-pin connector P1.

To install the Power Supply/Control Board Assembly, install 15-pin connector P1, and return all other listed parts in reverse order.

Y1 Oven Controlled Crystal Oscillator Removal and Installation (Option 001 Only)

To remove the Oven Controlled Crystal Oscillator, remove the following parts.

a. Front panel.

b. Top and bottom covers.

c. A1 Counter/Lock Assembly.

d. A2 Filter Board Assembly.

e. Right-side cover (counter air exhaust): six flat-head screws (including two for front panel).

f. Coaxial Tee MP1 (time base cables).

g. Yellow wire (+20V) from Power Supply/Control Board assembly.

h. Oscillator support bracket MP16: three flat-head screws (with lockwashers) on side frame and two flat-head screws on counter deck MP15.

i. Three 5/16 inch hex nuts (with lockwashers).

To install Oven Controlled Crystal Oscillator return all listed parts in reverse order.

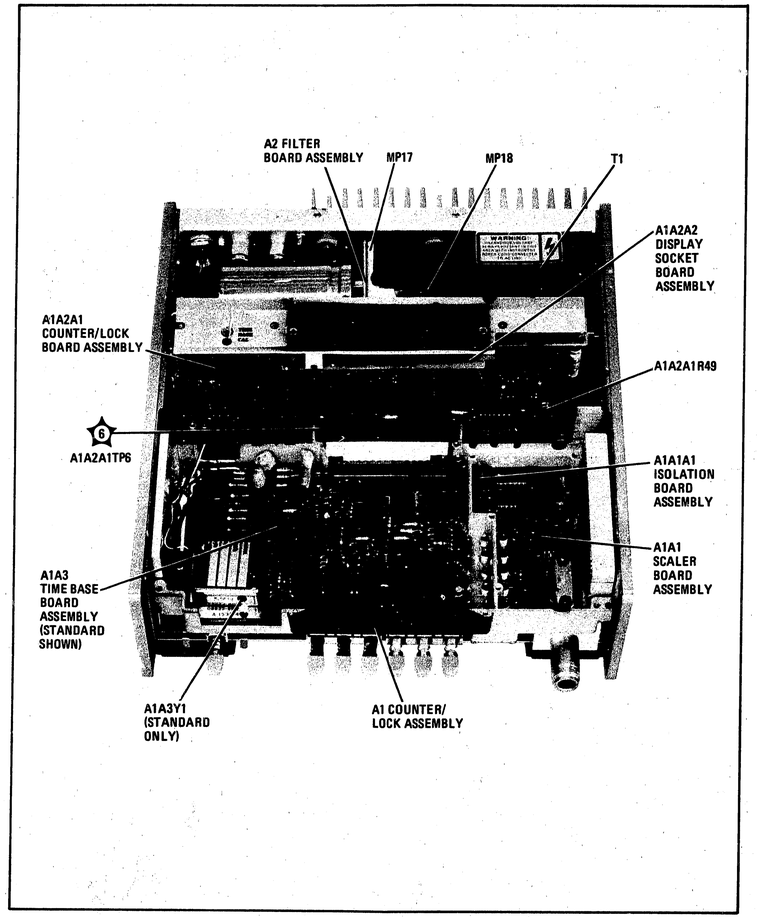


Figure 8-33. Top Internal View

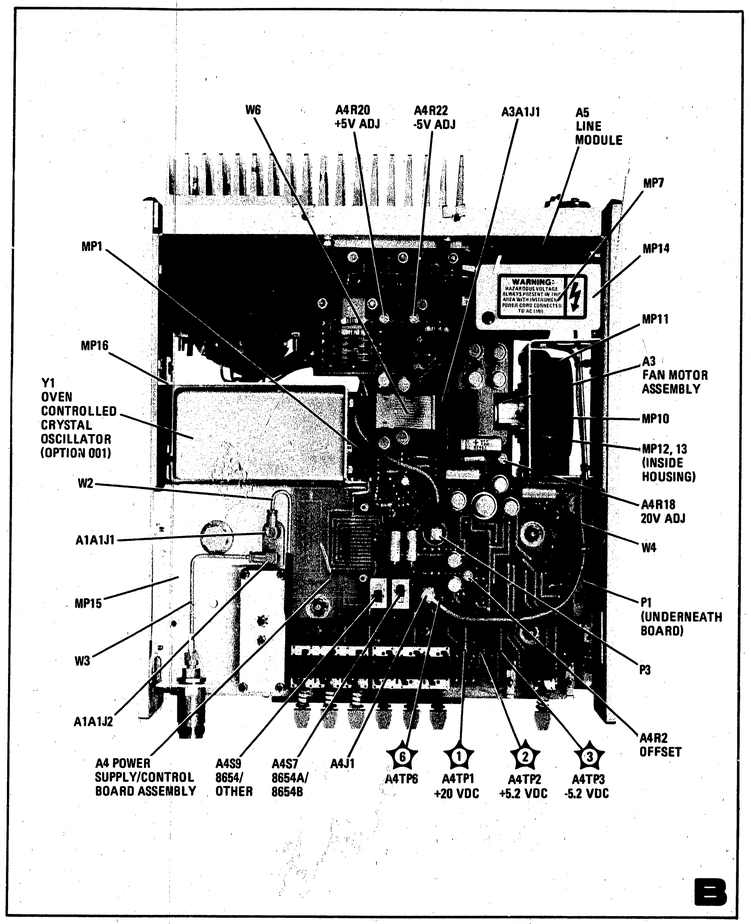


Figure 8-34. Bottom Internal View

MANUAL CHANGES

MANUAL CHANGES

MANUAL IDENTIFICATION

Model Number: 8655A
Date Printed: March 1976
Part Number: 08655-90001

SYNCHRONIZER/COUNTER

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
1602A	1
1608A	1,2
1621A	1–3
1630A	1–4
1743A	1–5
1751A	1–6

Serial Prefix or Number	Make Manual Changes
1845A	1–7
1919A	1–8
2001A	1–9
2019A	1–10
► 2324A	1–11

► NEW ITEM

ERRATA

Page 1-2, paragraph 1-15:
Delete the second sentence.

Page 1-3, Table 1-1:
In the Power specification (second column), change 400 Hz to 440 Hz.

Page 5-3, Table 5-1:
Add the following to the table:

A1A1R6	3	42.2 to 61.9Ω	Same as A1A1R2, R3

Page 6-4, Table 6-2:
A1L5: If this part fails, the recommended replacement is shown in **Change 5.**
A1MP43: The recommended replacement is 5021-0855 CD4 FILTER, WINDOW.
A1U3-9: If any of these parts fail, the recommended replacement is shown in **Change 10.**

Page 6-5, Table 6-2:
A1A1R6: Add an asterisk (*) to indicate a factory selected component.

►Page 6-8, Table 6-2:
Change A1A3L4, L5, L7 and L8 from 9100-4078 CD3 to 08640-80001.

NOTE

When replacing one of the above components, replace all the IC's and associated circuitry as described in Change 5.

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.

17 June 1983
17 Pages

HEWLETT PACKARD

ERRATA (Cont'd)

Page 6-9, Table 6-2:

A1A3U1, U2, U3 and U11: If any of these parts fail, the recommended replacements are shown in **Change 5.**

Page 6-10, Table 6-2:

A3: When replacing the A3 Fan Motor Assembly, replace cable W3 as described in **Change 7.**

NOTE

The above instruction only applies to instruments with serial numbers prefixed 1845A and below.

Page 6-12, Table 6-2:

W6: The new Fan Motor Cable Assembly, HP part number 8120-2385, is not interchangeable with the old part, HP part number 08655-60002 (used in instruments with serial numbers prefixed 1845A and below). If replacement of cable W6 (8120-2385) is required, also replace the A3 Fan Motor Assembly, HP part number 08655-60011.

S1: If this part fails, the recommended replacement is shown in **Change 10.**
Change part number for W7 to 08655-60016.

Page 6-14, Table 6-2:

Change MP15 to read as follows:

MP15: 08655-60024 COUNTER DECK (INCLUDES FOLLOWING BRACKET)
08655-00021 BRACKET (P/O MP15)

MP50: For recommended addition, see **Change 5.**

Service Sheet 2 (component locations):

Replace Figure 8-13 with the attached Figure 8-13. P/O A1A3 Time Base Board Assembly (Time Base) Component Locations.

Service Sheet 3, Table 8-3 (Troubleshooting):

In the instruction for step C1, change the second sentence to read, "Connect rear panel TIME BASE output to front panel EXT COUNT."

Service Sheet 3 (component locations):

Replace Figure 8-18 with the attached Figure 8-18. P/O A1A3 Time Base Board Assembly (Translator) Component Locations.

Service Sheet 3 (schematic):

Add an asterisk (*) to A1A1R6 to indicate a factory selected component.

Service Sheet 4 (component locations):

In Figure 8-20, change designators U7—U1 to U9—U3.

Service Sheet 4 (schematic):

Delete "NC" from pin 2 of U5A and add "+5.2V".

Service Sheet B (A3 Removal . . .)

Replace entire procedure with the following instructions:

A3 Fan Motor Assembly Removal and Installation

To remove the Fan Motor Assembly, remove the following parts:

a. Top and bottom covers.
b. A1 Counter/Lock Assembly.
c. Left-side cover (fan intake): four flat-head screws (two additional screws were removed in the A1 procedure).
d. A2 Filter Board Assembly.
e. DIP connector at A3A1J1 (part of ribbon cable W6).

ERRATA (Cont'd)

Service Sheet B (A3 Removal ...) (cont'd):

f. Blower support bracket (with Fan Motor Assembly): two flat-head screws on counter deck MP15, and two flat-head screws on left-side frame.
g. Blower housing MP10: two pan-head screws (with lockwashers), and one 5/16 inch hex nut (with lockwasher) on blower support bracket.
h. Blower wheel MP12: one allen setscrew.
i. Three flat-head screws on blower support bracket MP11.

To install the Fan Motor Assembly, return all listed parts in reverse order. When replacing blower wheel, position it on the shaft so that it does not rub against the support bracket.

Service Sheet 5 (component locations):

Replace Figure 8-26 with the attached Figure 8-26. P/O A1A3 Time Base Board Assembly (Low-Pass Filter) Component Locations.

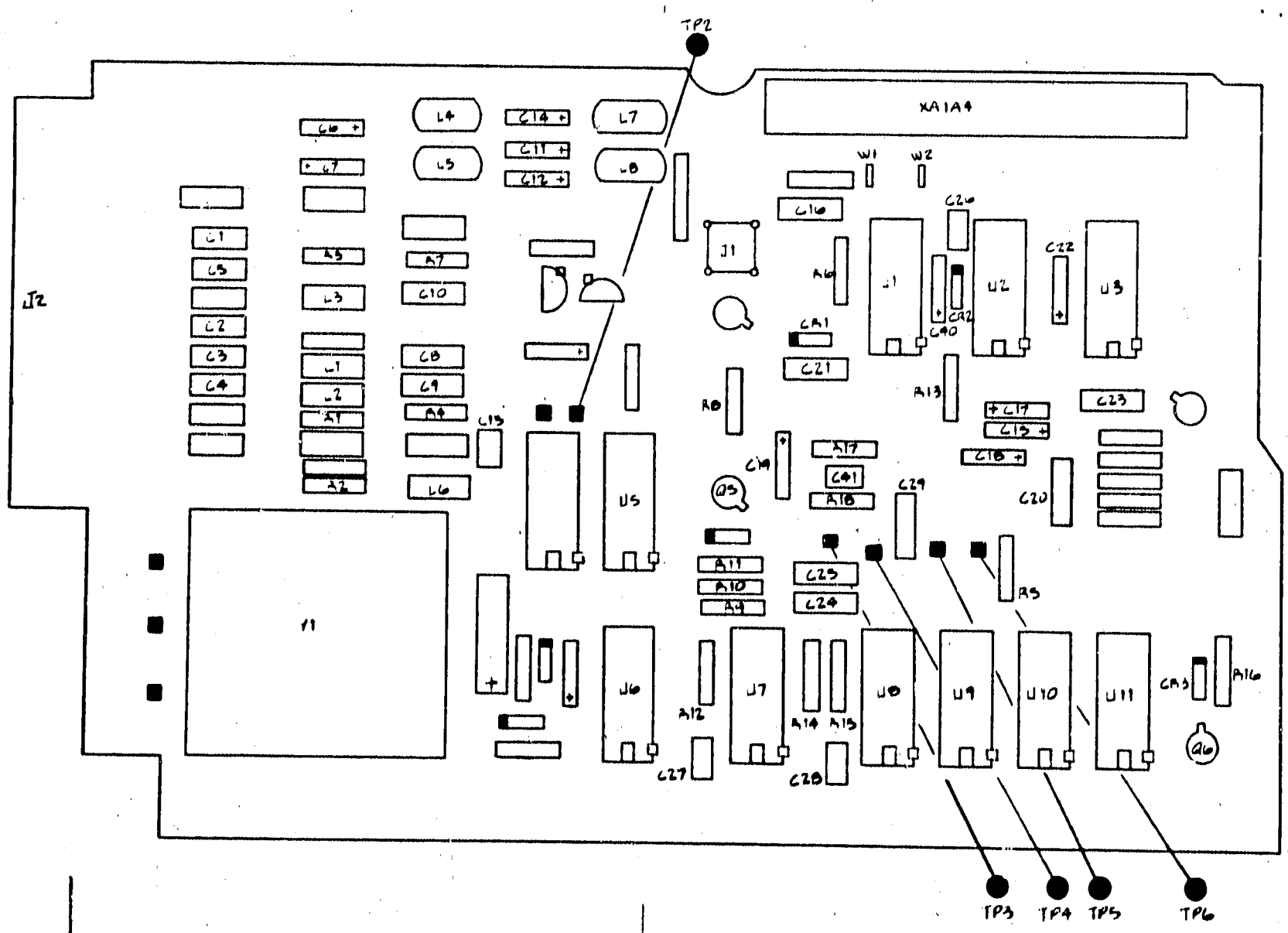


Figure 8-13. P/O A1A3 Time Base Board Assembly (Time Base) Component Locations

ERRATA (Cont'd)

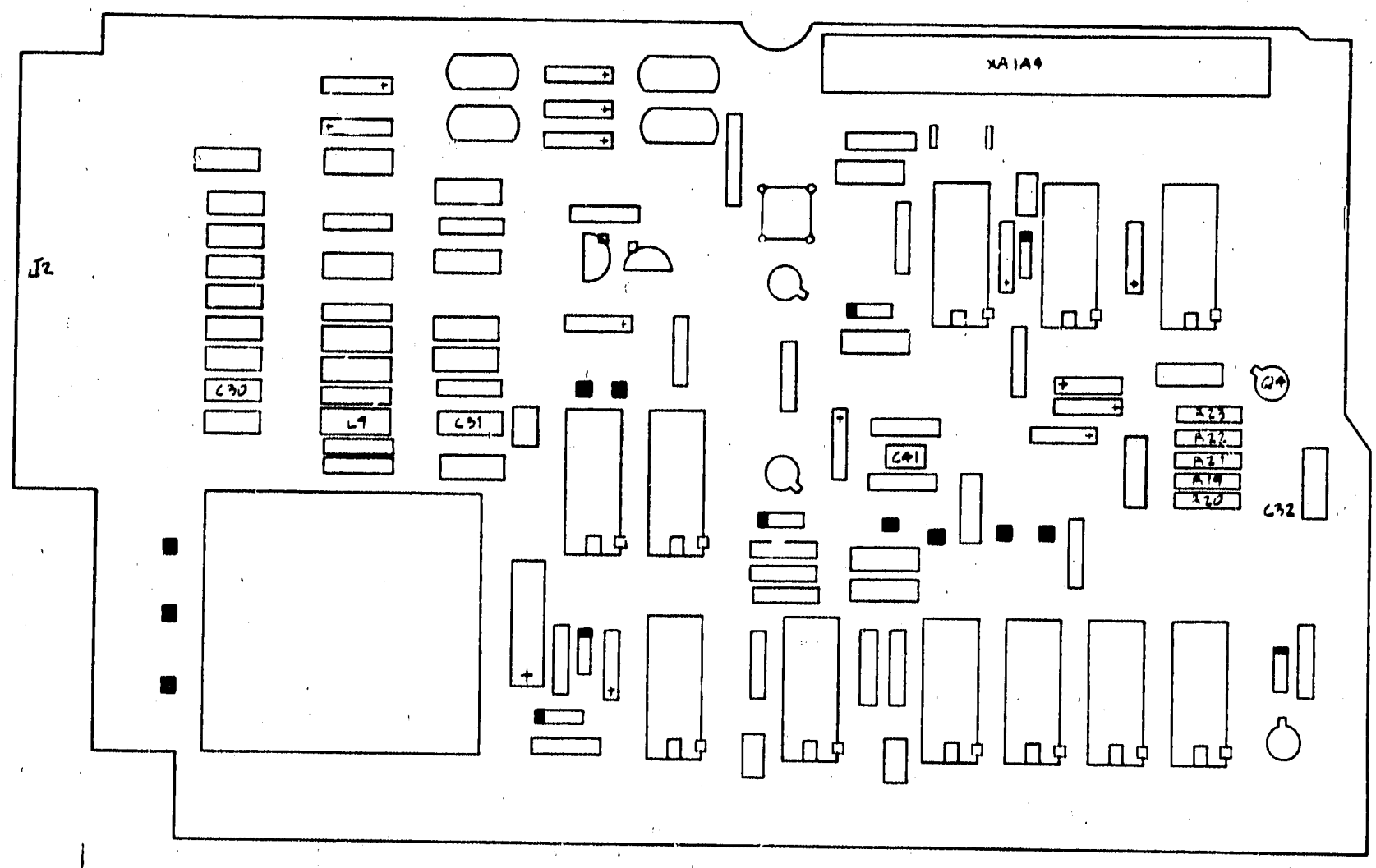


Figure 8-18. P/O A1A3 Time Base Board Assembly (Translator) Component Locations

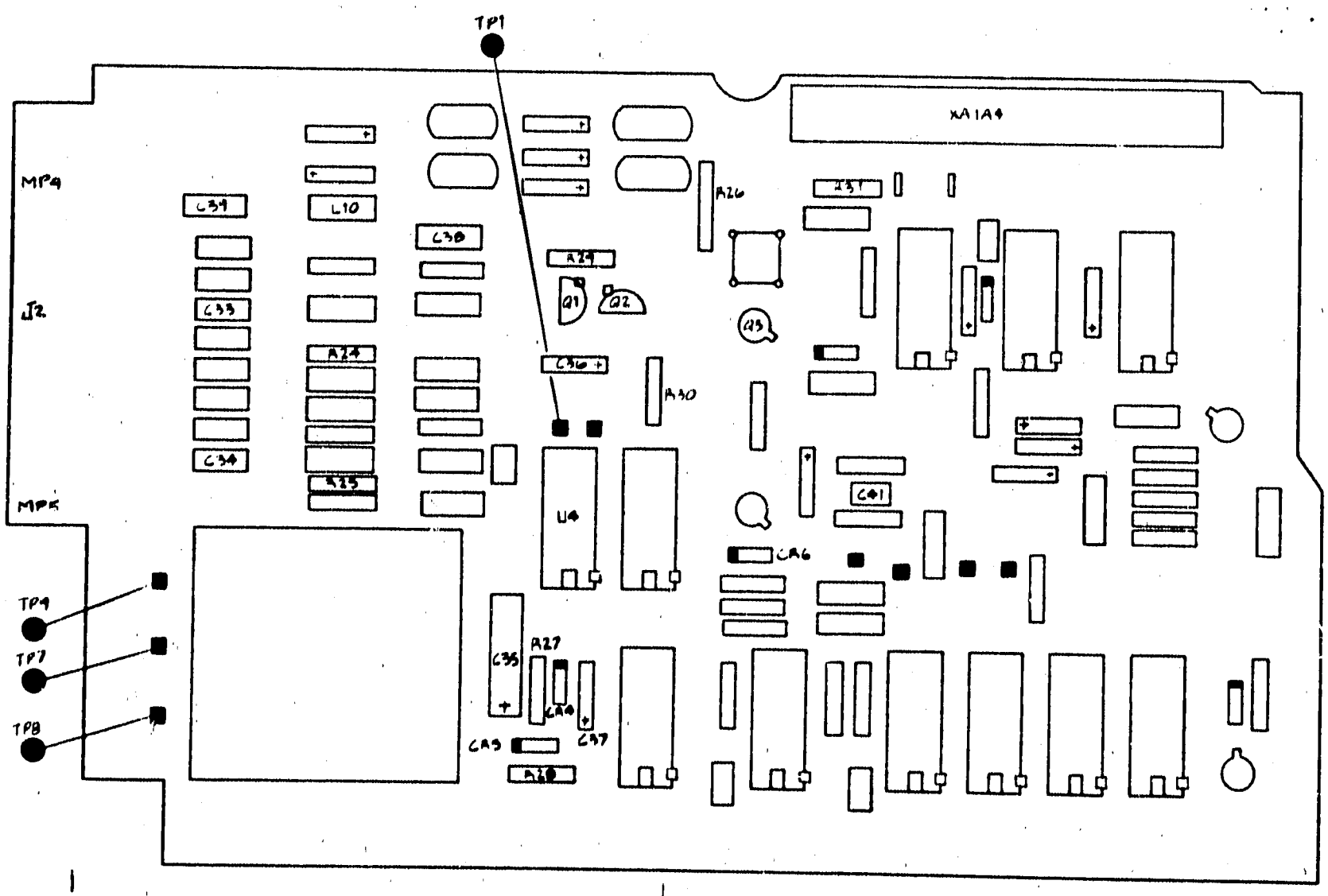


Figure 8-26. P/O A1A3 Time Base Board Assembly (Low-Pass Filter) Component Locations

CHANGE 1

Page 6-3, Table 6-2:
Add A1A3CR6 1901-0539 DIODE SCHOTTKY.

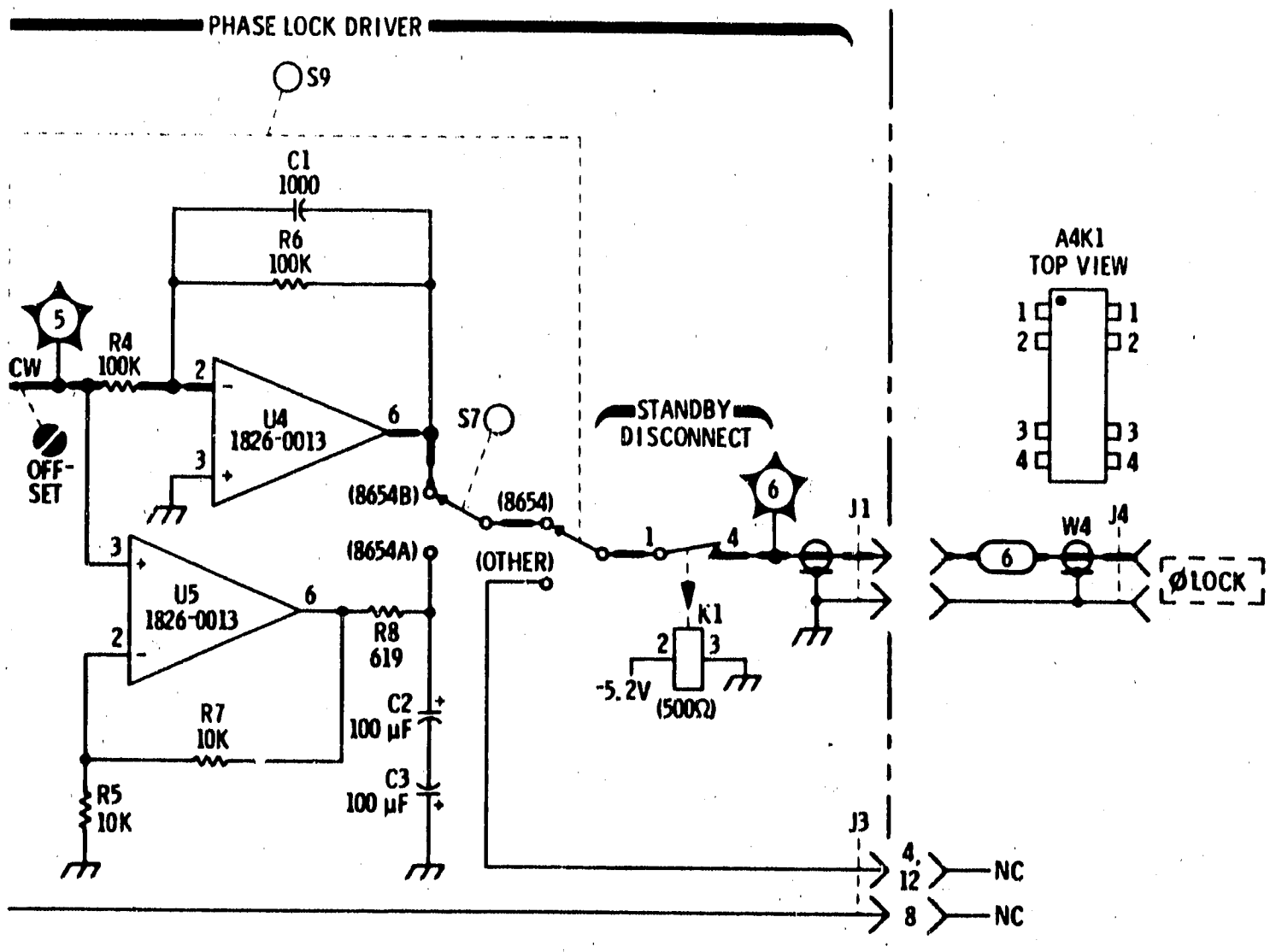
Service Sheet 2 (schematic):
On A1A3 Assembly, add diode CR6 with cathode connected to Q5 collector, and anode connected to Q5 base.

CHANGE 2

Page 6-4, Table 6-2:
Add A1MP44 08640-00102 INSULATOR, UNDER COUNTER TIME BASE.

Page 6-10, Table 6-2:
Add A4K1 0490-0916 RELAY, REED 1A 0.5A 50V CONT 5V-COIL.

Service Sheet 5 (schematic):
Replace appropriate portion of Figure 8-28 with the attached partial schematic.



P/O Figure 8-28. Phase Lock Circuits Schematic Diagram (P/O Change 2)

CHANGE 3

Page 6-4, Table 6-2:
Delete A1MP5.
Change A1MP13 to 2200-0704 SCREW-MACH (NYLON) 4-40 0.375-IN-LG, BDG-HD-SLT.

Page 6-7, Table 6-2:
Change A1A2A1R36 to 0698-7270 RESISTOR 26.1K 1% 0.05W F TC=0 ± 100.
Change A1A2A1R40 to 0698-7277 RESISTOR 51.1K 1% 0.05W F TC=0 ± 100.

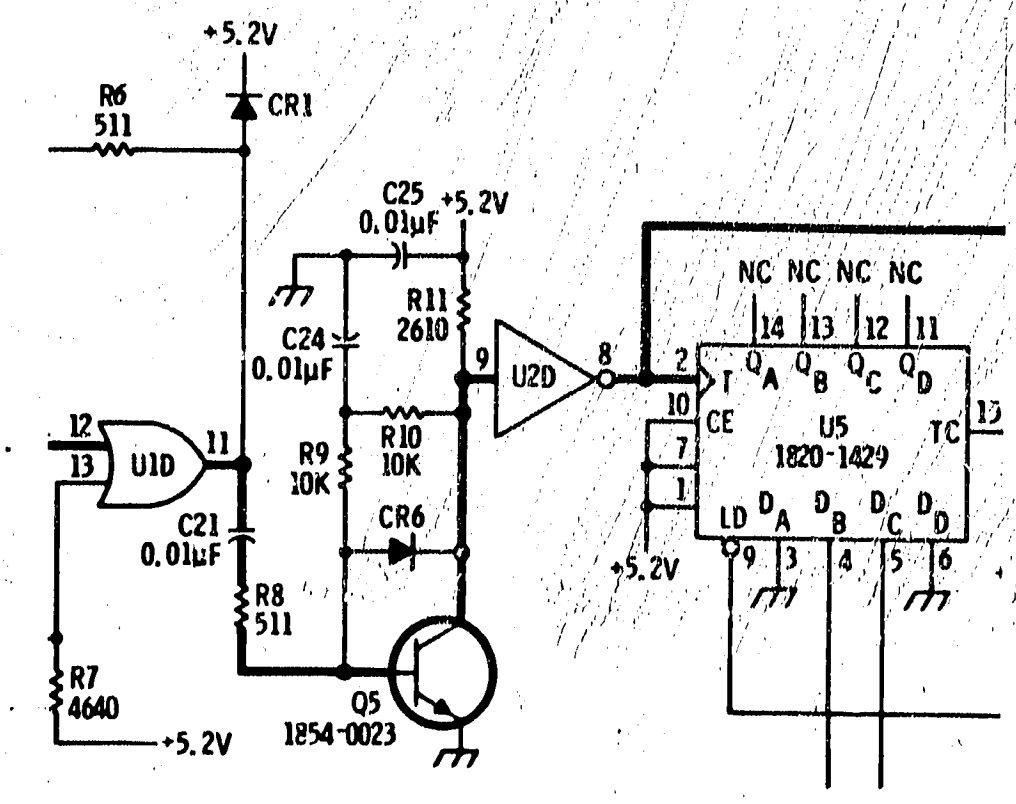
Service Sheet 5 (schematic):
On the A1A2A1 assembly, change R36 to 26.1 kΩ, and R40 to 51.1 kΩ.

Service Sheet A:
In the disassembly procedure for A1A1, change step e to read, "e. Two nylon screws (27) and two non-metallic washers (31) associated with A1U2 (29). Do not remove A1U2."
In the illustrated parts breakdown, delete item 28 (2 bushings).

CHANGE 4

Page 6-8, Table 6-2:
Add A1A3C40, 0180-0197 CAPACITOR-FXD 2.2 μF ±10% 20 VDC TA.

Service Sheet 2 (schematic):
On the A1A3 assembly, add 2.2 μF capacitor C40 between the +5.2V line and ground.
Replace appropriate portion of schematic with the attached partial schematic.



P/O Figure 8-14. Time Base Circuits Schematic Diagram (P/O Change 4)

CHANGE 5

Page 6-4, Table 6-2:
Change A1L5 to 9100-1612 COIL-MLD 330 NH 20% Q = 45 .155DX .375 LG.

Page 6-8 and 6-9, Table 6-2:
Make the following changes to the A1A3 assembly:
Change C1—C5, C13, C26, C30, C33, and C34 to 0160-3879 CAPACITOR-FXD .01 UF ±20% 100 VDC CER.
Change C29 to 0160-3454 CAPACITOR-FXD 220 PF ±10% 1 KVDC CER.
Add C41 0160-3876 CAPACITOR-FXD 47 PF ±20% 200 VDC CER.
Change R17 to 0698-3157 RESISTOR 19.6K 1% .125W F TC = 0±100.
Change R18 to 0757-0317 RESISTOR 1.33K 1% .125W F TC = 0±100.
Change U1 to 1820-1208 IC GATE TTL LS OR QUAD 2-INP SN74LS32N.
Change U2 to 1820-1053 IC SCHMITT-TRIG TTL HEX 1-INP SN7414N.
Change U3 to 1820-1197 IC GATE TTL LS NAND QUAD 2-INP SN74LS00N.
Change U11 to 1820-1490 IC CNTR TTL LS DECD ASYNCHRO SN74LS90N.

Page 6-14, Table 6-2:
Add MP50 08655-20035 MOTHER BOARD SUPPORT CLAMP.
2200-0111 SCREW-MACH 4-40 .5-IN LG PAN-HEAD POZI.

Service Sheet 2 (schematic):
Make the following changes to the A1A3 assembly:
Change C1—C5, C13, and C26 to 0.01 μF.
Change C29 to 220 pF.
Add C41, 47 pF, between pins 3 and 10 of U1C.
Change R17 to 19.6 kΩ.
Change R18 to 1330Ω.
Change the part number of U1 to 1820-1208.
Change the part number of U2 to 1820-1053.
Change the part number of U3 to 1820-1197.
Change the part number of U11 to 1820-1490.

Service Sheet 3 (schematic):
Change A1L5 to 0.33 μH.
Change A1A3C30 to 0.01 μF.

Service Sheet 5 (schematic):
Change A1A3C33 and C34 to 0.01 μF.

Service Sheet B:
In the **A4 Power Supply/Control Board Assembly Removal and Installation** procedure, change step k to read,
"k. Five pan-head screws (with lockwashers) and mother board support clamp MP50 (located under connector P1)."

CHANGE 6

Page 6-5, Table 6-2:

Change A1A2 to 08655-60027 COUNTER/DISPLAY ASSEMBLY. (INCLUDES A1A2A1 AND A1A2A2 ASSEMBLIES)
Change A1A2A1 to NSR, P/O A1A2, COUNTER/LOCK ASSEMBLY.

Pages 6-6, 6-7, and 6-8, Table 6-2:

Make the following changes to the A1A2A1 assembly listings:

Change C10 to 0160-2201 CAPACITOR-FXD 51 PF ±5% 300 VDC MICA.
Change C13 to 0160 -3533 CAPACITOR-FXD 470 PF ±5% 300 VDC MICA.
Change C14 to 0160-3875 CAPACITOR-FXD 22 PF ±5% 200 VDC CER.
Change C15 to 0140-0196 CAPACITOR-FXD 150 PF ±5% 300 VDC MICA.
Change C20 to 0180-0374 CAPACITOR-FXD 10 UF ±10% 20 VDC TA.
Change C25 to 0140-0205 CAPACITOR-FXD 62 PF ±5% 300 VDC MICA.
Add C26 0180-0374 CAPACITOR-FXD 10 UF ±10% 20 VDC TA.
Add C27 0160-3877 CAPACITOR-FXD 100 PF ±20% 200 VDC CER.
Add CR3 1901-0539 DIODE SCHOTTKY.
Change L2 to 9140-0112 COIL-MLD 4.7 UH 10% Q=33 .155 DX .375 LG—NOM.
Add L3 9140-0210 COIL-MLD 100 UH 5% Q=50 .155 DX .375 LG—NOM.
Delete R10.
Change R11 to 0698-7243 RESISTOR 1.96K 1% .05W F TC=0±100.
Change R12 to 0698-3444 RESISTOR 316 1% .125W F TC=0±100.
Change R31 to 0757-0280 RESISTOR 1K 1% .125W F TC=0±100.
Add R53 0698-7281 RESISTOR 75K 2% .05W F TC=0±100.
Add R54 0698-0090 RESISTOR 464 1% .5W F TC=0±100.
Change U2, U3, U15, and U16 to 1820-1197 IC GATE TTL LS NAND QUAD 2-INP SN74LS00N.
Change U4 to 1820-1199 IC INV TTL LS HEX 1-INP SN74LS04N.
Change U5 and U26 to 1820-1112 IC FF TTL LS D-TYPE POS-EDGE-TRIG SN74LS74N.
Change U13, U17, and U18 to 1820-1201 IC GATE TTL LS AND QUAD 2-INP SN74LS08N.
Change U14 to 1820-1208 IC GATE TTL LS OR QUAD 2-INP SN74LS32N.
Change U19-U24, and U28 to 1820-1684 IC CNTR TTL LS BCD UP/DOWN ASYNCHRO 9LS192PC.
Change U27 to 1820-1449 IC GATE TTL S OR QUAD 2-INP SN74S32N.

Make the following changes to the A1A2A2 assembly listings:

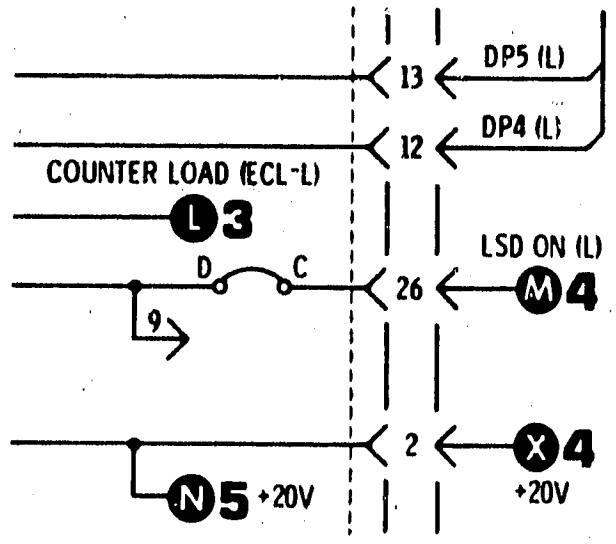
Change A1A2A2 to 08655-60026 DISPLAY SOCKET BOARD ASSEMBLY. (DOES NOT INCLUDE NUMERIC DISPLAY A1U3 THRU A1U9 .)
Add E1 1251-4244 CONNECTOR 11-PIN M POST TYPE.
Add E2 1251-4243 CONNECTOR 25-PIN M POST TYPE.
Delete MP1-MP3.
Delete P1A and P1B.
Add Q1 1853-0020 TRANSISTOR PNP SI PD=300 MW FT=150 MHz.
Add R1 0698-7224 RESISTOR 316 1% .05W F TC=0±100.

Service Sheet 2 of 2 Items
Replace improp. ite portion with the following partial assembly

CHANGE 6 (Cont'd)

Service Sheet 2 (schematic):

Replace appropriate portion with the following partial schematic:



P/O Figure 8-14. Time Base Circuits Schematic Diagram (P/O Change 6)

Service Sheet 4 (component locations):

Replace Figure 8-20 with the attached Figure 8-20.

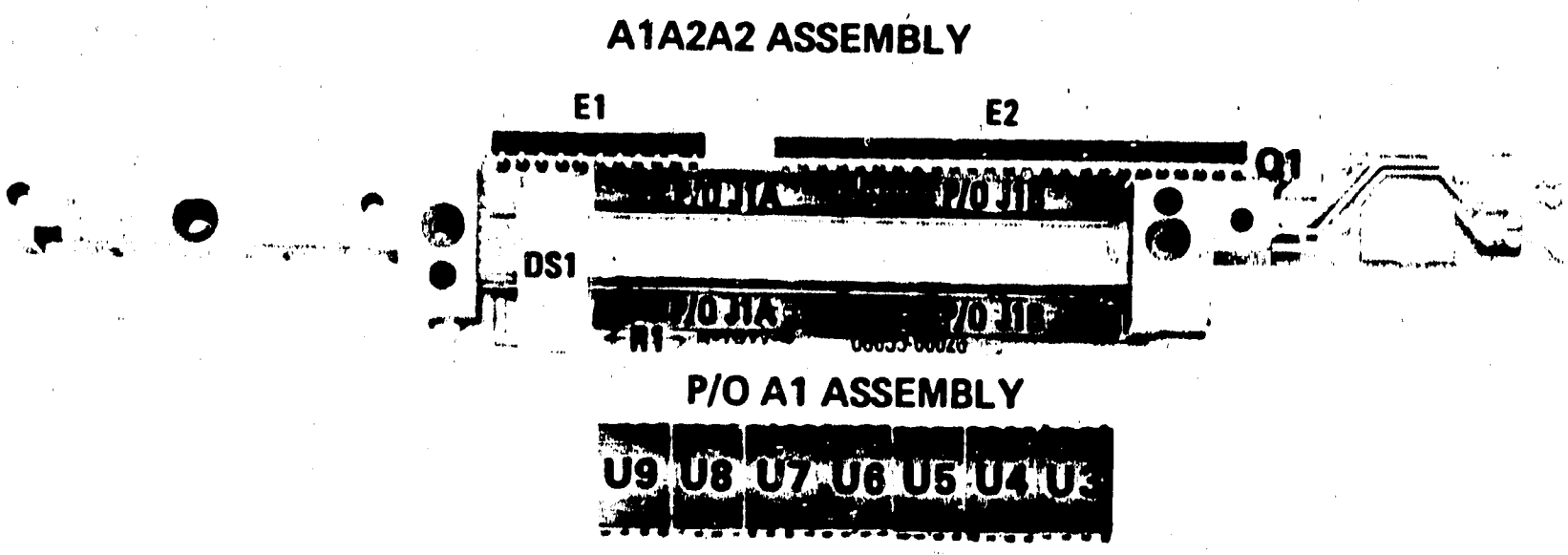


Figure 8-20. A1A2A2 Display Socket Board Assembly Component Locations (P/O Change 6)

CHANGE 6 (Cont'd)

Service Sheet 4 (component locations) (cont'd)

Replace Figure 8-21 with the attached Figure 8-21.

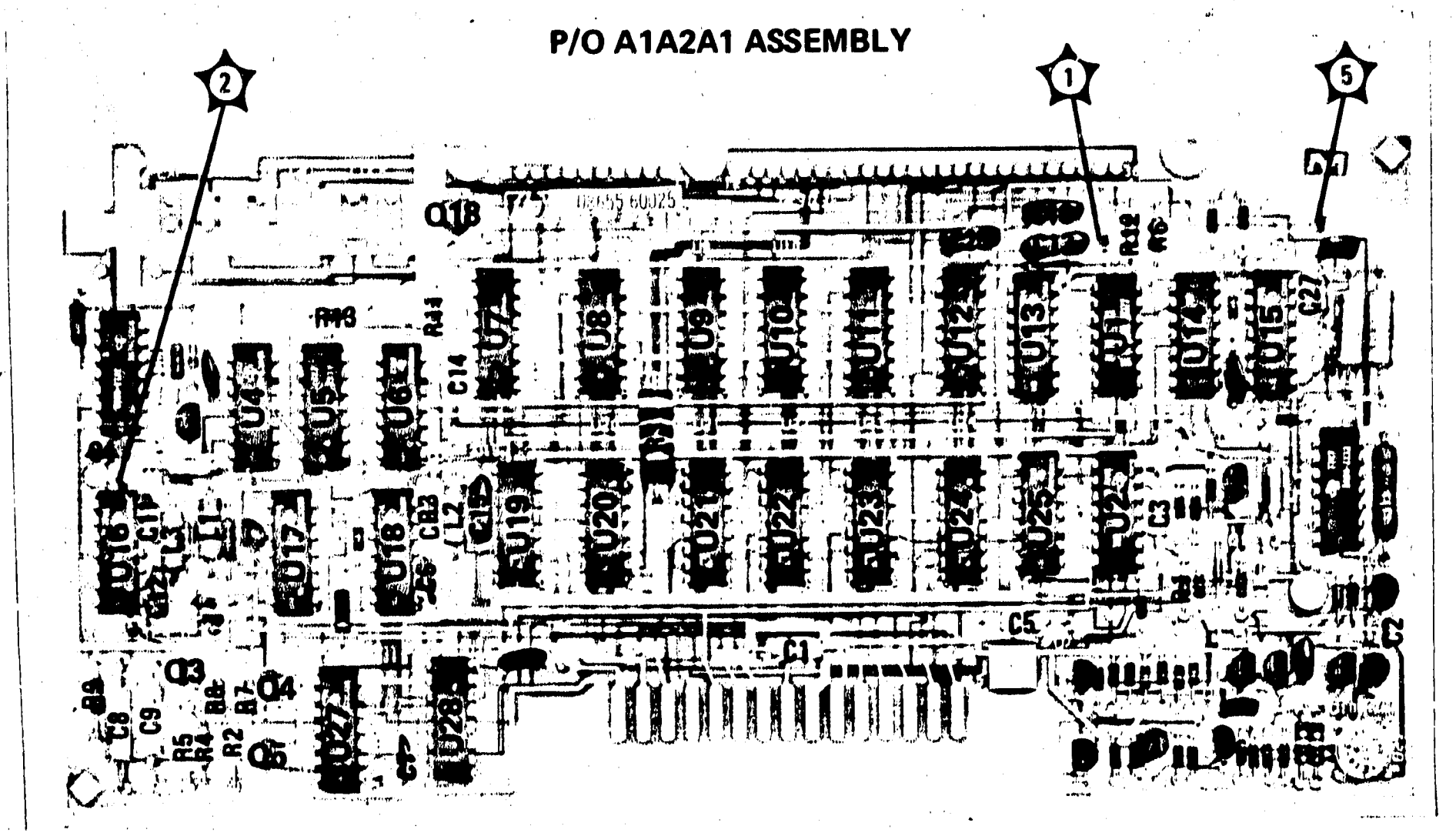


Figure 8-21. P/O A1A2A1 Counter/Lock Board Assembly (Up/Down Counter) Component Locations (P/O Change 6)

Service Sheet 4 (schematic):

Replace entire schematic with the attached fold out schematic.

Service Sheet 4A (Principles of Operation):

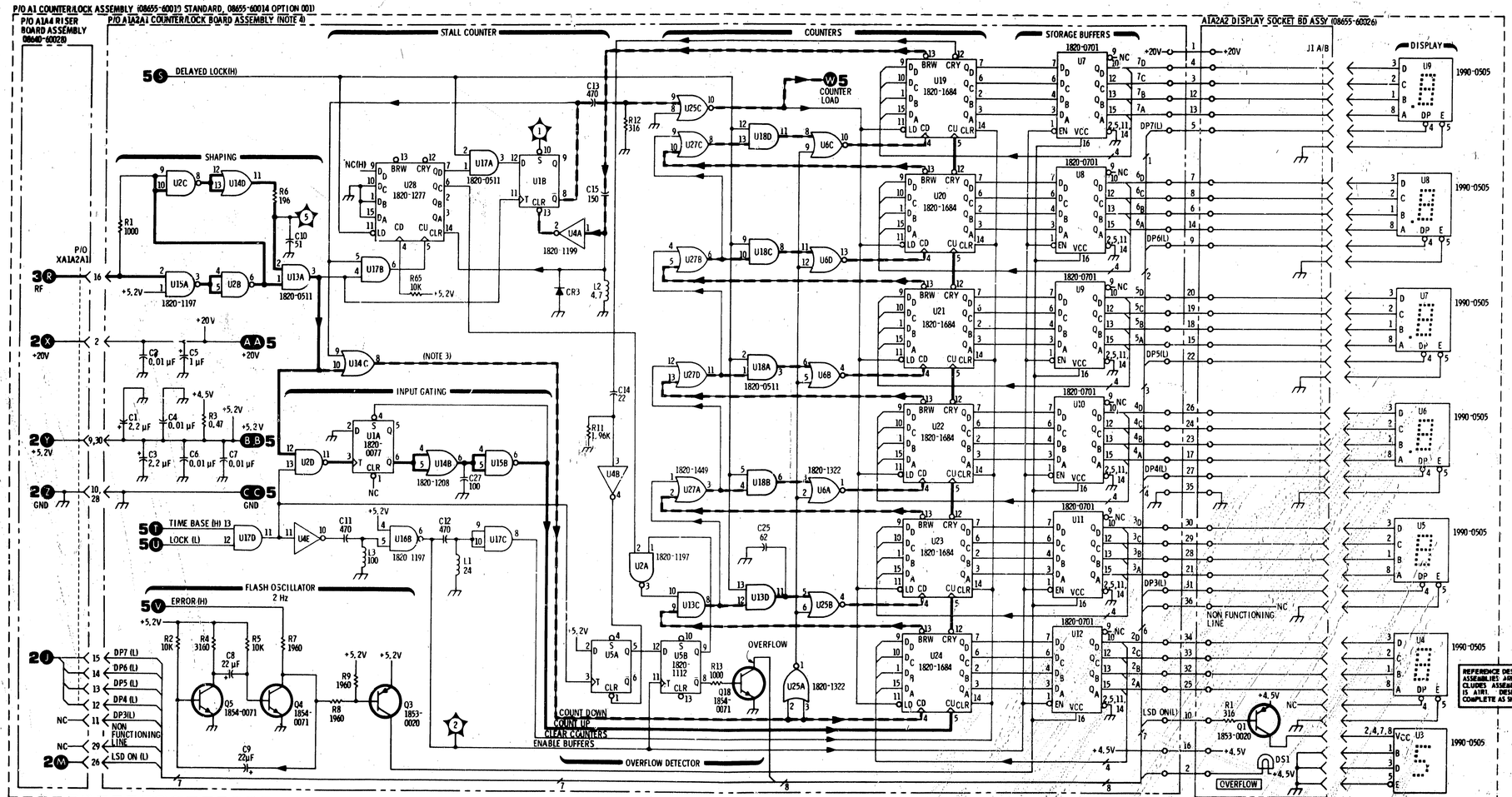
In the second paragraph under **Shaping and Input Gating** change "resistor R10" to "inductor L3" (1 place).

Service Sheet 4A (simplified diagram):

Change R10 to L3.

Service Sheet 5 (Principles of Operation):

In the second paragraph under **Phase Detector Circuit (A1A2A1)** change references to "C20" to "C20 and C26" (3 places).



NOTES

1. UNLESS OTHERWISE INDICATED: RESISTANCE IN OHMS; CAPACITANCE IN PICOFARADS; INDUCTANCE IN MICROHENRIES.
2. REFER TO FIGURE 8-10 FOR GENERAL SCHEMATIC DIAGRAM NOTES.
3. HEAVY DASHED LINE WITH ARROWS ⟶ INDICATES COUNT DOWN/PHASE LOCK SIGNAL FLOW.
4. A1A2A1 IS ONLY REPLACEABLE AS A1A2 (08655-60027) WHICH INCLUDES THE A1A2A2 COUNTER DISPLAY ASSEMBLY.

REFERENCE DESIGNATIONS

A1A2A1 ASSY	P/O A1 ASSY
C1-15, 25, 27	U3-9
CR3	A1A2A2 ASSY
J1	DS1
L1-L3	J1
Q3-5, 18	P1
R1-9, 11-13	P/O A1A4 ASSY
TP1, 2, 5	XA1A2A1
U1, 2, 4-25	
U27, 28	

DELETED: A1A2A1R10

INTEGRATED CIRCUIT VOLTAGE AND GROUND CONNECTIONS

REFERENCE DESIGNATIONS	PIN NUMBERS
A1A2A1U1, 2, 4-6, 13-18, 25, 27	+5.2V - 14 GND - 7
A1A2A1U7-12, 19-24, 28	+5.2V - 16 GND - 8
A1U3-9	+5.2V - 7 GND - 6

A1U3 THRU U9 TOP VIEW

PIN 1

REFERENCE DESIGNATIONS WITHIN OUTLINED (— - — - —) ASSEMBLIES ARE ABBREVIATED. FULL DESIGNATION INCLUDES ASSEMBLY NUMBER, e.g., R1 OF ASSEMBLY A1 IS A1R1. DESIGNATIONS OF OTHER COMPONENTS ARE COMPLETE AS SHOWN.

4
A1,A1A2A1,A1A2A2

► *Figure 8-22. Up/Down Counter and Display Schematic Diagram (Change 6)*

CHANGE 6 (Cont'd)

Service Sheet 5 (component locations):
Replace Figure 8-25 with the attached Figure 8-25.

P/O A1A2A1 ASSEMBLY

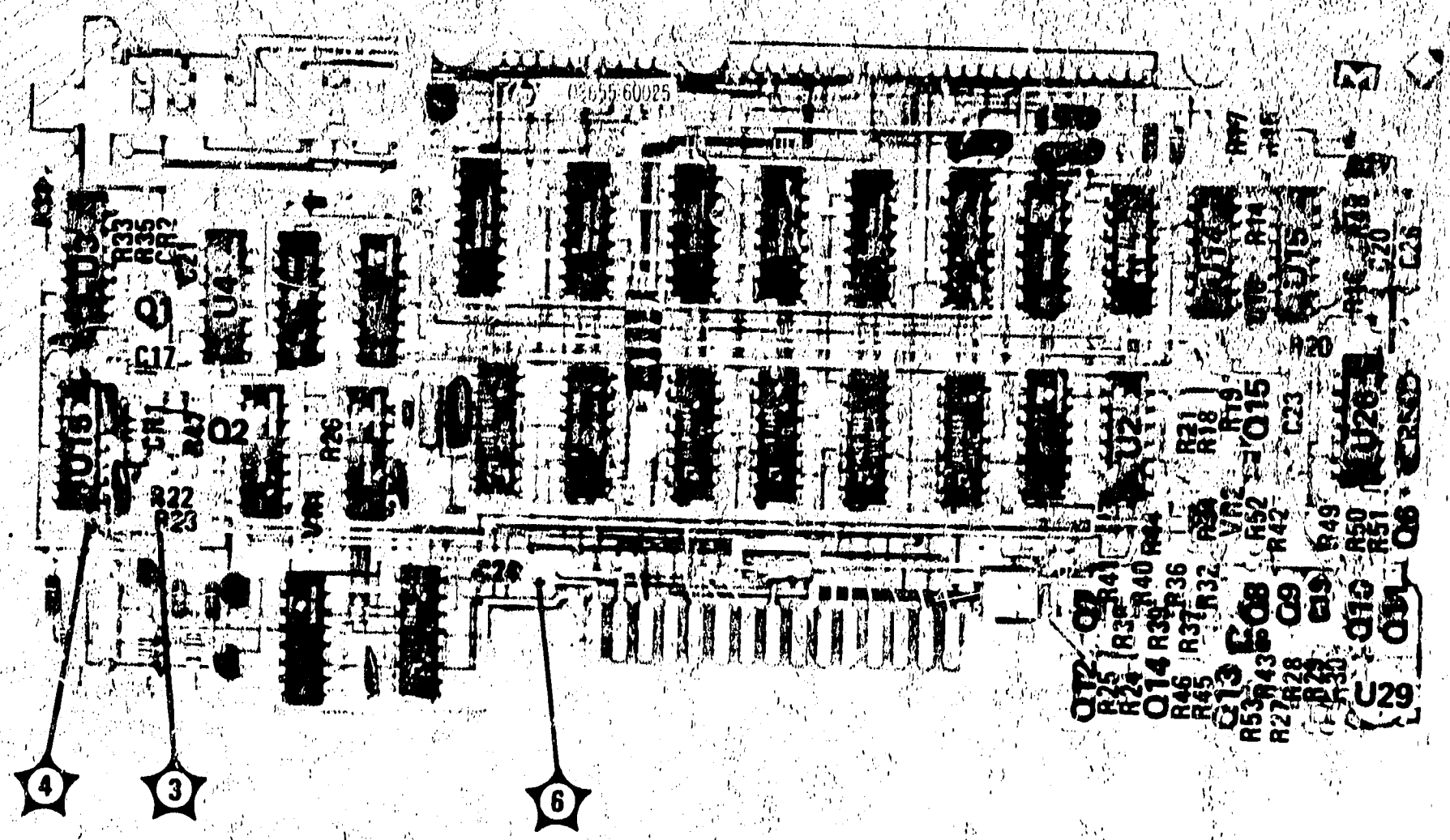


Figure 8-25. P/O A1A2A1 Counter/Lock Board Assembly (Phase Lock Circuit) Component Locations (P/O Change 6)

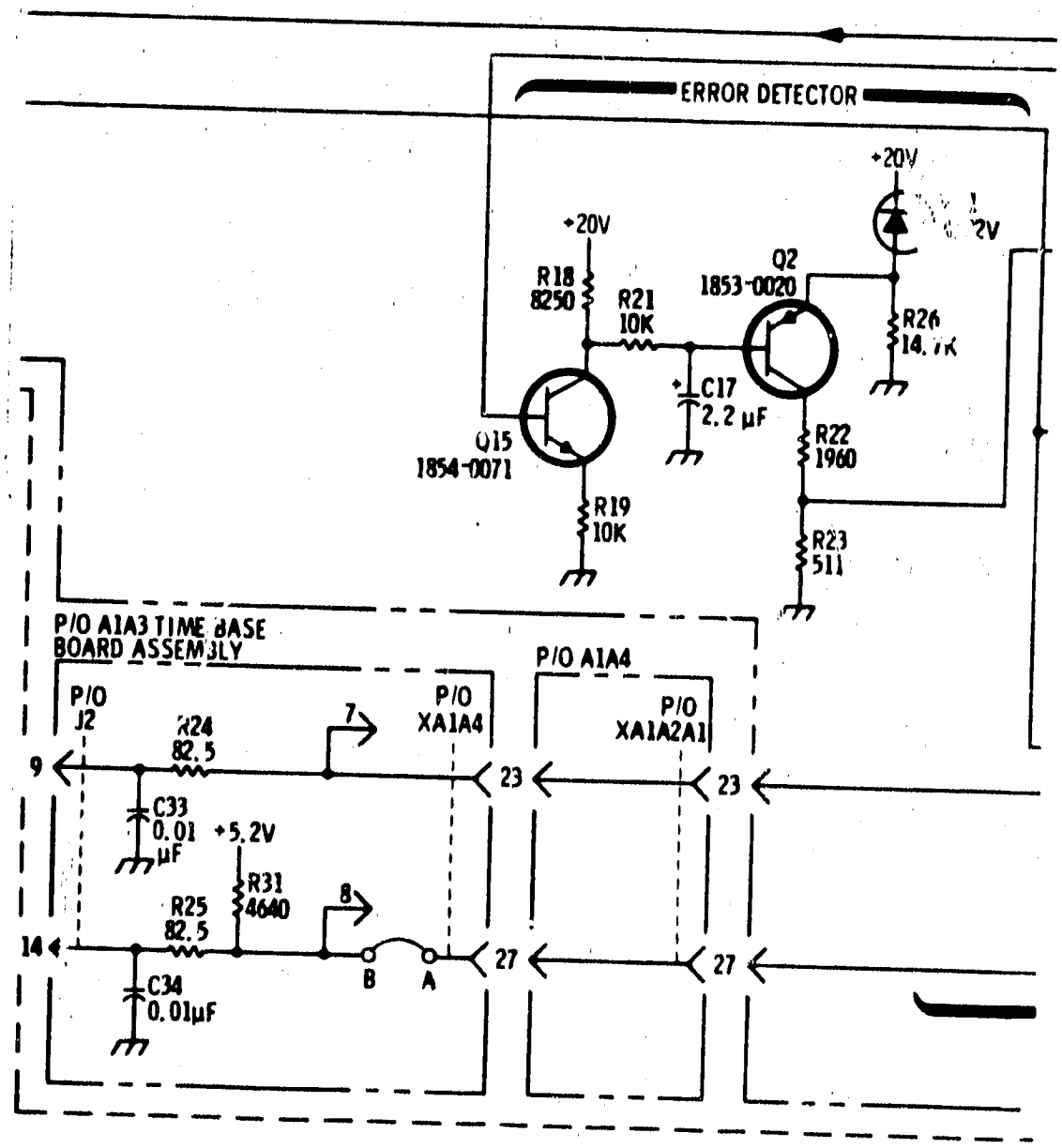
Service Sheet 5 (schematic):
Replace A1A2A1 assembly part number with "(NOTE 5)".

Under NOTES add the following:
"5. A1A2A1 IS ONLY REPLACEABLE AS A1A2 (08655-60027) WHICH INCLUDES THE A1A2A2 DISPLAY SOCKET BOARD ASSEMBLY."

CHANGE 6 (Cont'd)

Service Sheet 5 (schematic) (cont'd):

Replace appropriate portion of schematic with the following partial schematic:



P/O Figure 8-28. Phase Lock Circuits Schematic Diagram (P/O Change 6)

Make the following changes to the A1A2A1 assembly:

Change C20 to 10 µF.
Add C26, 10 µF, across C20 (negative polarity to ground).
Change R31 to 5110Ω.
Add R53, 75kΩ, between the base of Q13 and the collector of Q10.
Add R54, 464Ω, between the collector of Q11 and the +20V line.
Change the part number of U3 and U16 to 1820-1197.
Change the part number of U4 to 1820-1199.
Change the part number of U26 to 1820-1112.

CHANGE 7

Page 6-6 and 6-7, Table 6-2:

Change A1A2A1Q6 to 1855-0271 TRANSISTOR J-FET N-CHAN D-MODE SI (Check Digit is 1).
Add A1A2A1R55 0698-7260 RESISTOR 10K 1% .05W F TC = 0±100 (Check Digit is 7).

Page 6-12, Table 6-2:

Change W6 to 8120-2385 CABLE ASSEMBLY, FAN MOTOR (Check Digit is 2).

Service Sheet 5 (schematic):

Change the part number of A1A2A1Q6 to 1855-0271.
On the A1A2A1 Assembly add R55, 10K, from pin 5 of U3B to the +5.2V supply line.

CHANGE 8

Page 6-12, Table 6-2:

Change S1 to 3101-0415 SWITCH-SL DPDT MINTR .5A 125VAC/DC (Check Digit is 0).

CHANGE 9

Page 6-5, Table 6-2:

Change A1A1 to 08655-60039. Description remains the same (Check Digit is 2).

Make the following changes to the A1A1 assembly:

Change C10 to 0160-0573 CAPACITOR-FXD 4700 PF ±20% 100 VDC CER (Check Digit is 2).

Change R7 to 0757-0428 RESISTOR 1.62K 1% .125W F TC=0±100 (Check Digit is 1).

Delete R18.

Add R21 0698-7240 RESISTOR 1.47K 1% .05W F TC=0±100 (Check Digit is 3).

Change U3 to 1820-0802 IC GATE ECL NOR QUAD 2-INP (Check Digit is 1).

Page 6-7, Table 6-2:

Make the following changes to the A1A2A1 assembly:

Change U28 to 1820-1277 IC CNTR TTL LS DECD UP/DOWN SYNCHRO (Check Digit is 6).

Change U29 to 1826-0547 IC OP AMP DUAL 8 DIP-P (Check Digit is 3).

Service Sheet 3 (principles of operation):

In the **Pulse Swallowing Circuit (A1A1)** principle of operation, change "pin 2 of U3A" to "pin 6 of U3A" (3 places).

Service Sheet 3 (troubleshooting):

In the **RF Scaler Circuits Troubleshooting** table, change the instruction for step 5 to read: "Measure U3B (2)."

Service Sheet 3 (component locations):

Replace Figure 8-15 with the attached Figure 8-15.

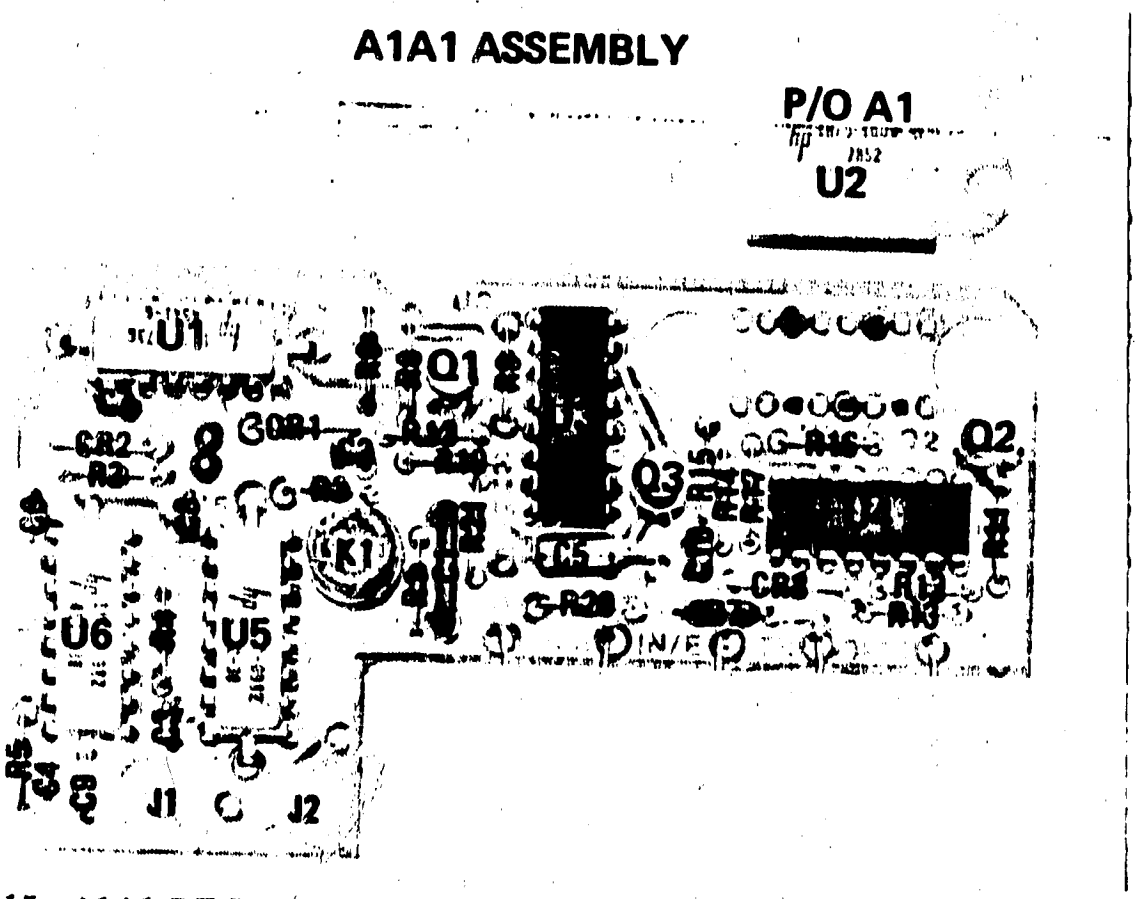


Figure 8-15. A1A1 RF Scaler Board Assembly Component Locations (P/O Change 9)

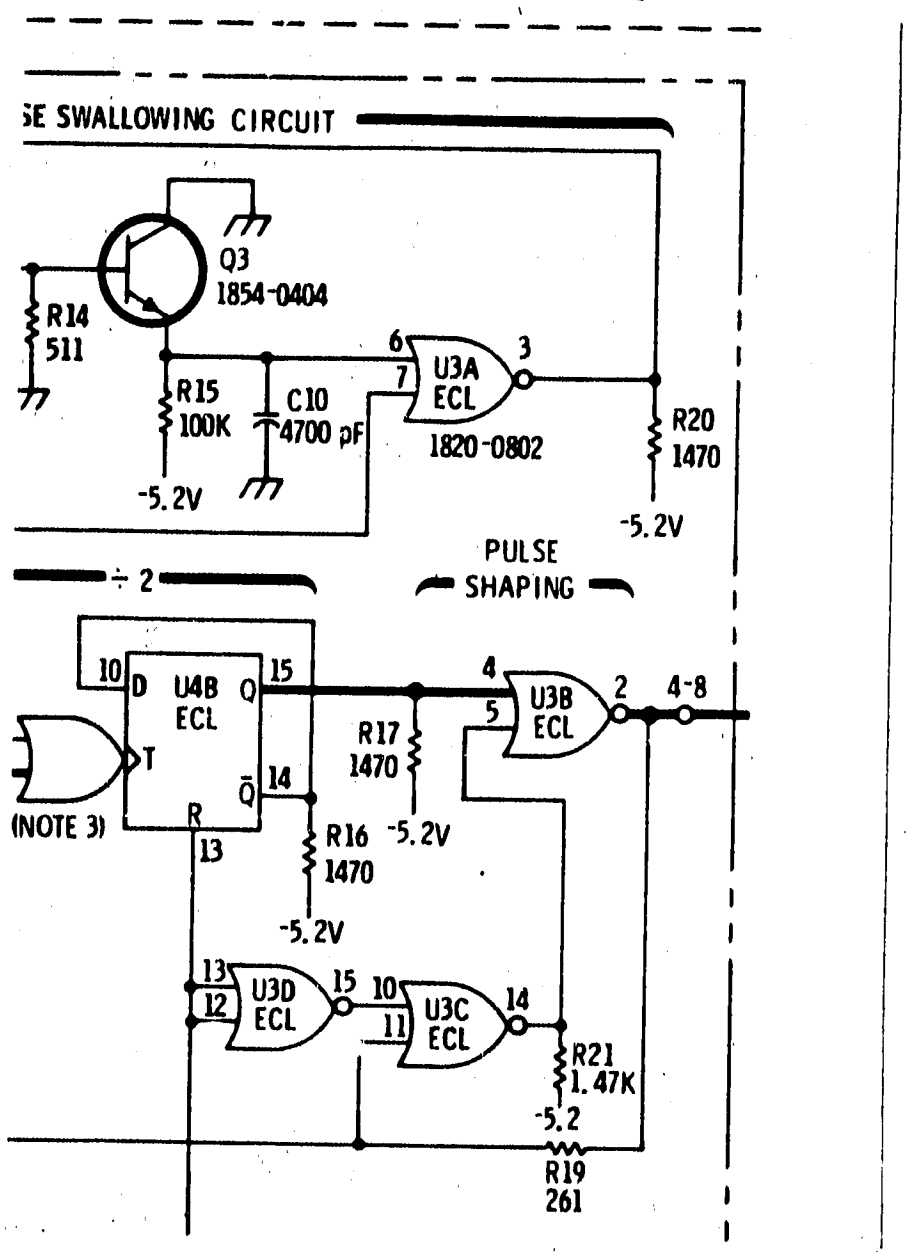
CHANGE 9 (Cont'd)

Service Sheet 3 (schematic):

Change the part number of A1A1 RF Scaler Board Assembly to 08655-60039.

Change A1A1R7 to 1620Ω.

Replace the appropriate portion of the schematic diagram with the attached partial schematic.



P/O Figure 8-19. RF Scaler Schematic Diagram (P/O Change 9)

In the **Integrated Circuit Voltage and Ground Connections** table change the voltage and ground connections of A1A1U3 to "–5.2-8" and "GND-1, 16".

Service Sheet 4 (schematic):

Change the part number of A1A2A1U28 to 1820-1277 (Refer to Change 6).

Service Sheet 5 (schematic):

Change the part number of A1A2A1U29 to 1820-0547.

CHANGE 10

Page 6-4, Table 6-2:

Change A1U3—9 to 1990-0330. The original parts were 1990-0462. Some instruments with the serial prefix associated with Change 10 may have 2990-0330 or 1990-0505 for these parts. Upon failure, the recommended replacement in all instruments is 1990-0330.

Page 6-7, Table 6-2:

Add A1A2A1R35 0698-7260 CD7 RESISTOR 10K 1% .05W F TC=0 ± 100.

Page 6-12, Table 6-2:

Change S1 to 3101-1903, same description.

CHANGE 10 (Cont'd)

Service Sheet 4 (schematic):

On the A1A2A1 Assembly add R65, 10k, from pin 4 of U28 to the +5.2V supply line.

Change A1U3—9 to 1990-0330. The original parts were 1990-0462. Some instruments with the serial prefix associated with Change 10 may have 1990-0330 or 1990-0505 for these parts. Upon failure, the recommended replacement in all instruments is 1990-0330.

CHANGE 11

Page 6-7, Table 6-3:

Change A1A2A1U29 to 1826-0785 (CD1) IC OP AMP LOW-BIAS-H-IMPD DUAL 8-DIP-C.

Page 6-9, Table 6-3:

Change A1A3XA1A4 and A1A4XA1A2A1 to 1251-6052 (CD8) CONNECTOR-PC EDGE 15-CONT/ROW 2-ROWS.

Page 6-11, Table 6-3:

Replace A4Q1 and A4Q2 with 1884-0244 (CD9) THYRISTOR-SCR VRRM=400, and 1205-0095 (CD0) HEAT SINK SGL TO-5/TO-39-CS.