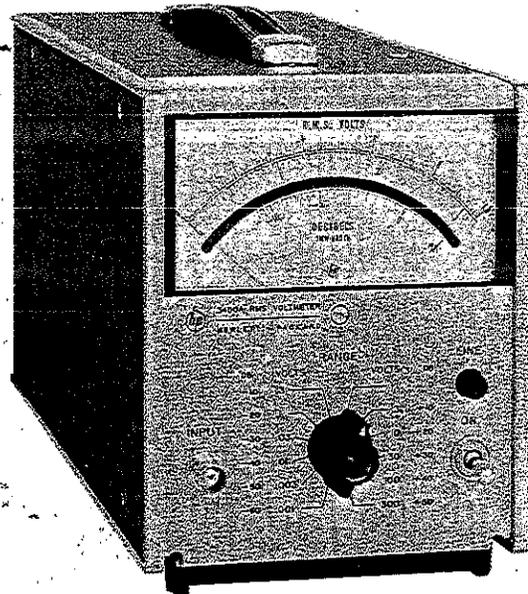


OPERATING AND SERVICE MANUAL

3400A RMS VOLTMETER



 **HEWLETT
PACKARD**

hp-3400A



OPERATING AND SERVICE MANUAL

MODEL 3400A RMS VOLTMETER

SERIAL NUMBERS

This manual applies directly to instruments with a serial number prefix of 2225.

WARNING

To help minimize the possibility of electrical fire or shock hazards, do not expose this instrument to rain or excessive moisture.

Manual Part Number 03400-90012
Microfiche Part Number 03400-90062

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

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CERTIFICATION

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

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment [except that in the case of certain components listed in Section I of this manual, the warranty shall be for the specified period]. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by -hp-. Buyer shall prepay shipping charges to -hp- and -hp- shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to -hp- from another country.

Hewlett-Packard warrants that its software and firmware designated by -hp- for use with an instrument will execute its programming instructions when properly installed on that instrument. Hewlett-Packard does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

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

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

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SAFETY SUMMARY

The following general safety precautions must be observed during all phases of operation, service, and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. Hewlett-Packard Company assumes no liability for the customer's failure to comply with these requirements. This is a Safety Class 1 instrument.

GROUND THE INSTRUMENT

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

DO NOT OPERATE IN AN EXPLOSIVE ATMOSPHERE

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

KEEP AWAY FROM LIVE CIRCUITS

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

DO NOT SERVICE OR ADJUST ALONE

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

DO NOT SUBSTITUTE PARTS OR MODIFY INSTRUMENT

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

DANGEROUS PROCEDURE WARNINGS

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

WARNING

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

SAFETY SYMBOLS

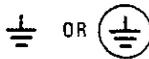
General Definitions of Safety Symbols Used On Equipment or In Manuals.



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



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



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



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



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



Alternating current (power line).



Direct current (power line).



Alternating or direct current (power line).

WARNING

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

CAUTION

The CAUTION sign denotes a hazard. It calls attention to an operating procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

NOTE:

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

SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This section contains general information about the Model 3400A RMS Voltmeter (Figure 1-1). Included are: description of instrument, purpose, instrument identification, equipment supplied and accessory equipment available. Also included is a table of instrument specifications.

1-3. DESCRIPTION AND PURPOSE

1-4. The Model 3400A RMS Voltmeter measures the actual root-means-square (RMS) value of ac voltages between 100 microvolts and 300 volts. Frequency range is from 10 Hz to 10 MHz. Full scale measurements of nonsinusoidal waveforms with crest factors (ratio of peak voltage to rms voltage) of 10 can be made.

1-5. Ac voltages are measured with a specified full-scale accuracy of $\pm 1\%$ from 50 Hz to 1 MHz, $\pm 2\%$ from 1 MHz to 2 MHz, $\pm 3\%$ from 2 MHz to 3 MHz, and $\pm 5\%$ from 10 Hz to 50 Hz and 3 MHz to 10 MHz. A single front panel control selects one of 12 voltage or decibel ranges.

1-6. The Model 3400A crest factor rating is 10:1 which enables full scale readings for pulses which have a 1% duty cycle. At 1/10th of full scale, pulse trains with 0.01% duty cycle (100:1 crest factor) can be accurately measured.

1-7. The Model 3400A provides a dc output which is proportional to the front panel meter reading. By using this voltage to drive auxiliary equipment, the Model 3400A functions as an rms ac-to-dc converter.

1-8. SPECIFICATIONS

1-9. Table 1-1 contains the specifications for the Model 3400A.

1-10. INSTRUMENT AND MANUAL IDENTIFICATION

1-11. Hewlett-Packard uses a two-section serial number. If the first section (serial prefix) of the serial number on your instrument does not agree with those on the title page of this manual, change sheets supplied with the manual will define the differences between your instrument and the Model 3400A described in this manual. Some serial numbers may have a letter separating the two sections of the number. This letter indicates the country in which the instrument was manufactured.

1-12. EQUIPMENT SUPPLIED

1-13. The equipment supplied with each Model 3400A is listed and described in Table 1-2.

Table 1-1. Model 3400A Specifications

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|--------|------|------|------|-------|-------|-----|-----|-----|-----|-----|-----|------|------|------|------|------|-------|-----|--------|-----|-----|-----|-----|--|
| <p>VOLTAGE RANGE: 1 mV to 300 V full scale, 12 ranges.</p> <p>DB RANGE: -72 to +52 dBm (0 dBm = 1 mW in 600Ω).</p> <p>FREQUENCY RANGE: 10 Hz to 10 MHz.</p> <p>RESPONSE: Responds to rms value (heating value) of input signal.</p> <p>METER ACCURACY:* from 1/10 scale to full scale is % of Full Scale (20°C to 30°C)**</p> <table border="1"> <tr> <td>10Hz</td> <td>50Hz</td> <td>1MHz</td> <td>2MHz</td> <td>3MHz</td> <td>10MHz</td> </tr> <tr> <td>±5%</td> <td>±1%</td> <td>±2%</td> <td>±3%</td> <td>±3%</td> <td>±5%</td> </tr> </table> <p>AC-to-DC CONVERTER ACCURACY: % of Full Scale (20°C to 30°C)*</p> <table border="1"> <tr> <td>10Hz</td> <td>50Hz</td> <td>1MHz</td> <td>2MHz</td> <td>3MHz</td> <td>10MHz</td> </tr> <tr> <td>±5%</td> <td>±0.75%</td> <td>±2%</td> <td>±3%</td> <td>±3%</td> <td>±5%</td> </tr> </table> <p>OUTPUT: Negative 1 V dc into open circuit for full-scale deflection, proportional to meter deflection; 1mA maximum; nominal source impedance 1000Ω.</p> <p>OUTPUT NOISE: < 1 mV RMS.</p> | 10Hz | 50Hz | 1MHz | 2MHz | 3MHz | 10MHz | ±5% | ±1% | ±2% | ±3% | ±3% | ±5% | 10Hz | 50Hz | 1MHz | 2MHz | 3MHz | 10MHz | ±5% | ±0.75% | ±2% | ±3% | ±3% | ±5% | <p>CREST FACTOR: (ratio of peak-to-rms amplitude of input signal): 10:1 at full scale (except where limited by maximum input), inversely proportional to meter deflection (e.g., 20:1 at half-scale, 100:1 at tenth-scale).</p> <p>INPUT IMPEDANCE 0.001 V to 0.3 V range; 10 MΩ shunted by < 50 pF; 1.0 V to 300 V range; 10 MΩ shunted by < 20 pF. AC-coupled input.</p> <p>AC OVERLOAD: 30dB above full scale or 800 V peak, whichever is less, on each range.</p> <p>MAXIMUM DC INPUT: 600 V on any range.</p> <p>RESPONSE TIME: For a step function, < 5 seconds to respond to final value.</p> <p>POWER: 115 or 230 V ± 10%, 48 to 440 Hz. approximately 7 watts.</p> <p>WEIGHT: Net 7 1/4 lbs. (3, 3kg); shipping 10 lbs. (5kg).</p> <p>OVERALL DIMENSIONS: 6 1/2" high; 5 1/8" wide; 11 1/16" deep.</p> <p>STORAGE TEMPERATURE: -10°C to +60°C.</p> |
| 10Hz | 50Hz | 1MHz | 2MHz | 3MHz | 10MHz | | | | | | | | | | | | | | | | | | | | |
| ±5% | ±1% | ±2% | ±3% | ±3% | ±5% | | | | | | | | | | | | | | | | | | | | |
| 10Hz | 50Hz | 1MHz | 2MHz | 3MHz | 10MHz | | | | | | | | | | | | | | | | | | | | |
| ±5% | ±0.75% | ±2% | ±3% | ±3% | ±5% | | | | | | | | | | | | | | | | | | | | |

* The 3400A may show a zero offset with no voltage applied to the input terminals.

** Temperature Coefficient: ±.15%/°C over range of 0°C to 20°C and 30°C to 55°C.

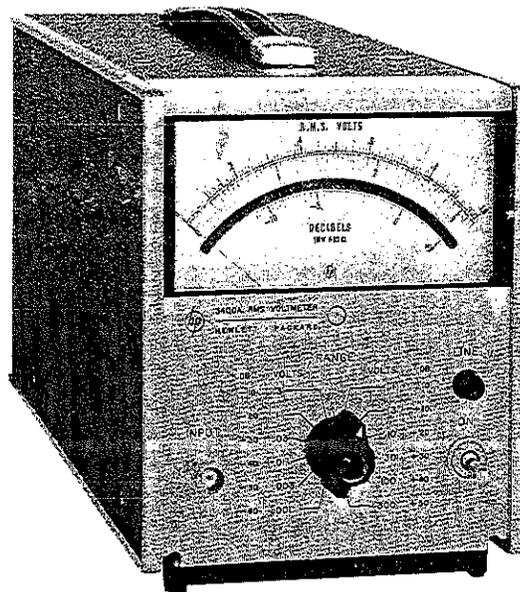


Figure 1-1. 3400 RMS Voltmeter

1-14. ACCESSORY EQUIPMENT AVAILABLE

1-15. The accessory equipment available is listed in Table 1-3. For further information contact your local -hp- Sales and Service Office.

Table 1-2. Equipment Supplied

| Identification Number | Quantity | Description |
|-----------------------|----------|-----------------------------------|
| 10110B | 1 | Adapter (BNC to dual banana jack) |
| 8120-1348 | 1 | Power Cord |
| 03400-90011 | 1 | Operating and Service Manual |

Table 1-3. Accessory Equipment Available

| Identification Number | Description |
|-----------------------|--|
| 10503A | Cable (Male BNC to male BNC, 48 inches) |
| 11001A | Cable (Male BNC to dual banana plug, 45 inches) |
| 11002A | Test Lead (dual banana plug to alligator clips, 60 inches) |
| 11003A | Test Lead (dual banana plug to probe and alligator clip, 60 in.) |
| 456A | Current Probe |

SECTION II

INSTALLATION

2-1. INTRODUCTION

2-2. This section contains information and instructions necessary for installation and shipping of the -hp- Model 3400A RMS Voltmeter. Included are initial inspection procedures, power requirements, installation information, and instructions for repackaging for shipment.

2-3. INITIAL INSPECTION

2-4. The -hp- Model 3400A RMS Voltmeter received a careful mechanical and electrical inspection before shipment. As soon as the Model 3400A is received, verify that the contents are intact and as ordered. Although the instrument should be free of marks and scratches and in perfect electrical condition, it should be inspected for any physical damage which may have been incurred in transit. Also test the electrical performance of the instrument using the procedures given in paragraph 5-5. If any physical damage or electrical deficiency is found, refer to the warranty on the inside front cover of this manual. Should shipping of the instrument become necessary, refer to paragraph 2-14 for repackaging and shipping instructions.

2-5. POWER REQUIREMENTS

2-6. The Model 3400A can be operated from any ac source of 115- or 230- volts ($\pm 10\%$), at 48 to 440 cycles. With the instrument disconnected from the ac power source, move the slide switch (located on the rear panel) until the desired line voltage value appears. The ac line fuse is a 0.25 amp, fast blow type for 115- or 230-volt operation. Power dissipation is approximately 7 watts.

2-7. The Model 3400A is equipped with a three-prong power cord. To protect operating personnel, it is necessary to preserve the grounding feature of this plug when using a two contact ac outlet. Use a three-prong to two-prong adapter and connect the green pigtail lead on the adapter to ground.

2-8. INSTALLATION

2-9. The Model 3400A is a submodular unit suitable for bench top use. However, when used in combination with other submodular units it can be bench and/or rack mounted. The -hp- combining case and adapter frame are designed for this purpose.

2-10. Combining Case (-hp- Models 1051A or 1052A)

2-11. The combining case is a full-module unit which accepts various combinations of submodular units. Being a full-module unit, it can be bench or rack mounted and is analogous to any full-module instrument.

2-12. Adapter Frame (-hp- Part No. 5060-0797)

2-13. The adapter frame is a rack frame that accepts any combination of submodular units. It can be rack mounted only. For additional information, address inquiries to your -hp- Sales and Service Office.

2-14. REPACKAGING FOR SHIPMENT

2-15. The following paragraphs contain a general guide for repackaging for shipment. Refer to paragraph 2-16 if the original container is to be used; 2-17 if it is not. If you have any questions, contact your local -hp- Sales and Service Office.

NOTE

If the instrument is to be shipped to Hewlett-Packard for service or repair, attach a tag to the instrument identifying the owner and indicate the service or repair to be accomplished; include the model number and full serial number of the instrument. In any correspondence, identify the instrument by model number, serial number, and serial number prefix.

2-16. If original container is to be used, proceed as follows:

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

b. Ensure that the container is well sealed with strong tape or metal bands.

2-17. If original container is not to be used, proceed as follows:

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

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

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

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

SECTION III

OPERATING INSTRUCTIONS

3-1. INTRODUCTION

3-2. This section consists of instructions and information necessary for the operation of the -hp- Model 3400A RMS Voltmeter. This section contains identification of controls and indicators, turn-on procedures, and operating instructions. Also included is a discussion of the applications for the Model 3400A.

3-3. CONTROLS AND INDICATORS

3-4. Each operating control, connector, and indicator located on the Model 3400A is identified and described in Figure 3-1. The description of each component is keyed to an illustration of that component which is included within the figure.

3-5. TURN ON PROCEDURE

3-6. To turn on the Model 3400A, proceed as follows:

- a. Set 115/230 switch (7, Figure 3-1) to correct position for input line voltage.
- b. Apply ac voltage to Model 3400A by plugging power cord into input power jack (8) ac receptacle.
- c. Operate power switch (4) to ON; ensure that LINE indicator (3) lights.

NOTE

Allow five minutes for the Model 3400A to warm up and stabilize before making a reading.

3-7. OPERATING INSTRUCTION

CAUTION

Do not measure signal above 80 volts with 10 to 1 crest factor. Otherwise, the maximum input rating (800 volts peak) will be exceeded. When measuring signals up to 80 volts RMS with a 10 to 1 crest factor, use the BNC to dual banana jack, accessory 10110A, supplied with the instrument, or other input test leads and connections that will withstand the maximum input of 800 volts peak.

3-8. To operate the Model 3400A as an rms voltmeter proceed as follows:

- a. Attach test lead to INPUT connector (6, Figure 3-1). (See Table 1-3 for a list of test leads available.)

- b. Set RANGE switch (5) to 300 VOLTS position.

CAUTION

When measuring an ac signal superimposed on a DC level, always set the range switch to the 300 volt position. A high voltage transient due to the application of a DC voltage will damage the input circuitry.

- c. Connect test lead to point to be measured.
- d. Rotate RANGE switch counterclockwise until meter (1) indicates on upper two thirds of scale.

3-9. APPLICATIONS

3-10. The Model 3400A can be used in conjunction with other test instruments to measure the rms value of ac signal with a dc component, measure rms current and act as an rms ac-to-dc converter. For additional information on special applications, contact your -hp- Sales and Service Office.

3-11. RMS Value Of AC Signals With DC Component

3-12. Since the 3400A is an ac device it will measure only the rms value of the ac component. If it is necessary to include the rms value of the dc component when measuring a signal use an -hp- Model 3468A Digital Multimeter to measure the dc component. Substitute the reading from the Model 3468A and Model 3400A in the following formula: The ac signal (up to 800V peak) may be superimposed on a dc level of up to 600 V.

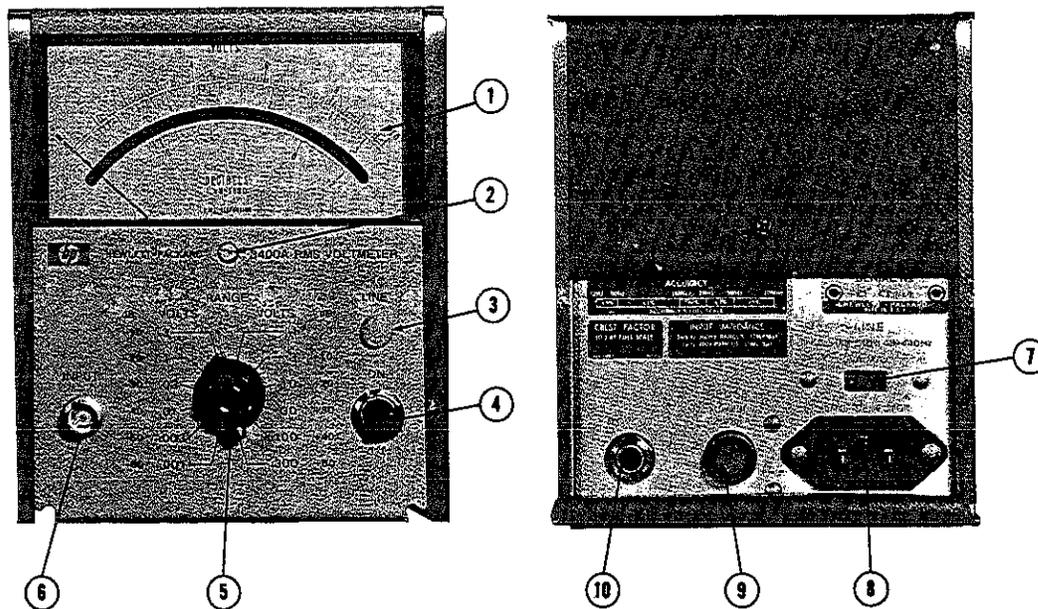
$$e_{rms} = \sqrt{e_{ac}^2 + e_{dc}^2}$$

3-13. RMS Current

3-14. To measure rms current, use an -hp- Model 456A AC Current Probe. This probe clips around the current conductor and provides an output voltage that is proportional to the current being measured. Using this method, rms currents of one milliampere to one ampere can be measured.

3-15. RMS AC-TO-DC Converter

3-16. Since the Model 3400A is provided with a dc output (10, Figure 3-1) which is proportional to the meter deflection, it can be used as a linear rms ac to dc converter. The dc output can be used to drive an -hp- Model 3468A Digital Multimeter for high resolution measurements and/or an -hp- Model 680 Strip Chart Recorder. External loading does not affect the meter accuracy so that both the meter and dc output can be used simultaneously. A plug for DC OUT jack may be purchased under -hp- Part No. 1251-0067.



- ① Direct reading meter: dc meter which indicates rms voltage level of input signal.
- ② Mechanical zero adjustment: screwdriver adjustment for zero of direct reading meter.
- ③ LINE ON pilot lamp: neon lamp which indicates when power is applied to instrument and power switch is ON.
- ④ Power switch: two-position toggle switch which applies 115- or 230-volts ac to instrument.
- ⑤ RANGE switch: 12-position rotary switch which selects various attenuation ranges available within Model 3400A.
- ⑥ INPUT connector: BNC jack which enables application of input signal to instruments measuring circuits.
- ⑦ 115/230-volt switch: two-position slide switch which sets instrument to operate from either a 115- or 230-volt ac source.
- ⑧ Input power jack: three-prong jack which enables application of line voltage to instruments power supply circuits.
- ⑨ 115V/230V .25A FUSE: 0.25 ampere fuse which provides protection against line voltage surges.
- ⑩ DC OUT jack: telephone-type jack which provides negative 1-volt dc out at full scale deflection, output is proportional to meter deflection, output impedance is 1000 ohms.

A telephone plug for the DC OUT jack may be purchased under -hp- Part No. 1251-0067.

Figure 3-1. Model 3400A Controls and Indicators

SECTION IV

THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This section contains the theory of operation of the Model 3400A RMS Voltmeter. Included is a general and detailed description of the theory of operation.

4-3. GENERAL DESCRIPTION

4-4. The operation circuitry of the Model 3400A consists of two attenuators, an impedance converter, a video amplifier, a chopper op amp, a thermocouple pair, and a direct reading meter.

4-5. A signal being measured with the Model 3400A is applied to input attenuator A1 through the INPUT jack, located on the Model 3400A front panel. The input attenuator has an input impedance of over 10 megohms and provides two ranges of attenuation. The output of the input attenuator is applied to impedance converter A2. The impedance converter is a non-inverting unity voltage gain amplifier. It presents a high impedance to the input signal and provides a low impedance output to drive the second attenuator A3. The second attenuator provides 6 ranges in a 1, 3, 10 sequence. The two attenuators are switched to provide 12 ranges of attenuation.

4-6. The output of the second attenuator is amplified by video amplifier A4. The video amplifier is a wideband, five stage amplifier. The overall gain of the video amplifier is controlled by an ac feedback loop. The ac output of the amplifier is applied to TC401; one of the thermocouples of the thermocouple pair.

4-7. The dc output of TC401 is applied to the chopper op amp (U601) which modulates the voltage. The resultant modulated signal is then amplified and, after the amplification, the signal is demodulated back to dc volts. This voltage is the output of the chopper op amp. The value of the voltage is proportional to the dc input voltage.

4-8. The output of the chopper op amp is applied to a filter and also to TC402, the second thermocouple of the thermocouple pair. The output of the filter is applied to an output amp (A4) which is used to drive the meter (M1).

4-9. The thermocouple pair TC401 and TC402 acts as a summing point for the ac output of the video amplifier (A4) and the dc output of the chopper op amp. The difference in the heating effect of these voltages is the dc input to the chopper op amp. This difference input is amplified and is fed to TC402 and also, after going through the output amplifier (U602), to the meter (M1). This voltage represents the rms value of the ac signal applied to the 3400A's INPUT jack. By using two "matched" thermocouples and measuring the difference, the output of the chopper op amp will be linear. Using two thermocouples also provides temperature stability.

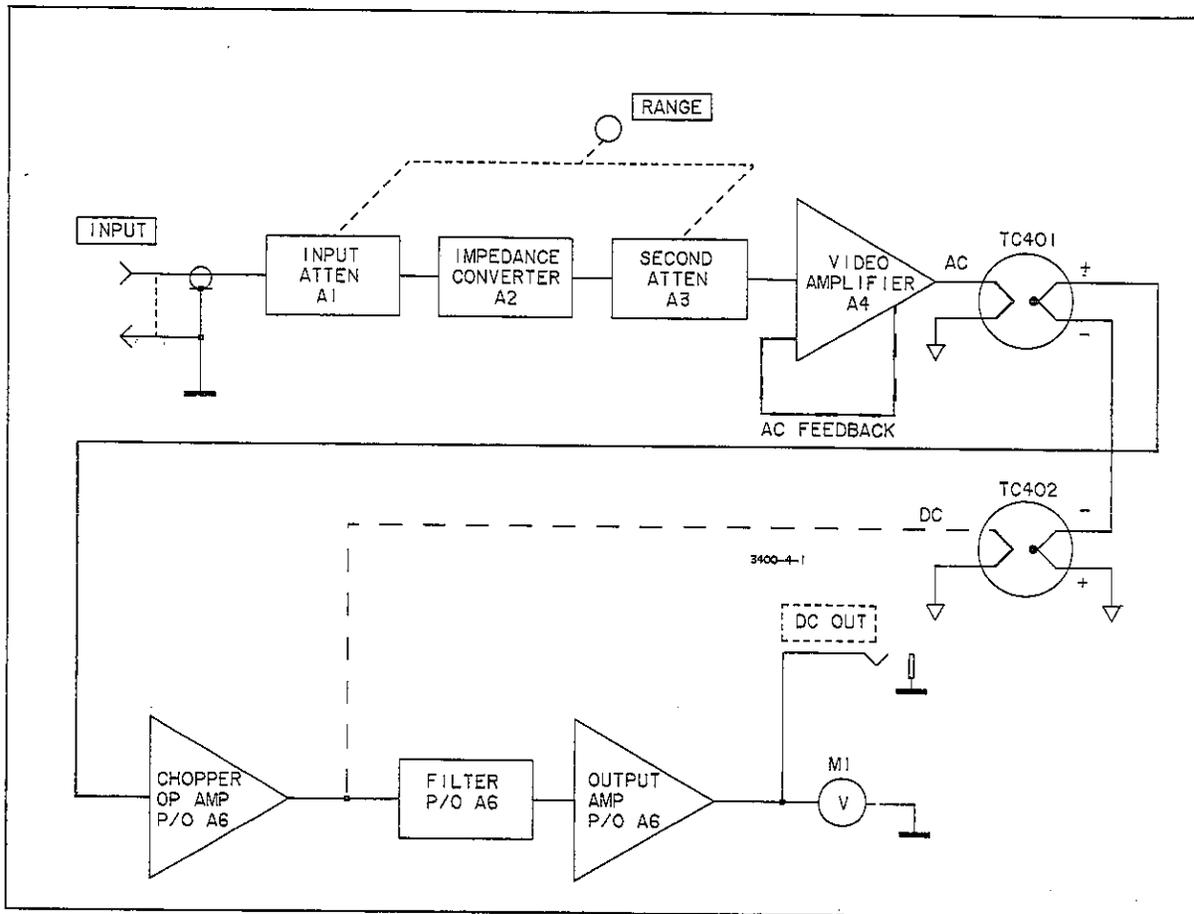


Figure 4-1. Block Diagram

4-10. The dc voltage driving meter M1 is also available at the DC OUT jack, located at the rear of the Model 3400A.

4-11. DETAILED DESCRIPTION

4-12. Input Attenuator Assembly A1

4-13. The input attenuator assembly is a capacitive-compensated attenuator which provides two ranges of attenuation for the 12 positions of the RANGE switch. See input attenuator schematic diagram illustrated on Figure 6-1.

4-14. When the RANGE switch is positioned to one of the six most sensitive ranges (.001 to .3 VOLTS), the attenuator output voltage is equal to the input voltage. When the RANGE switch is positioned to one of six highest ranges (1 to 300 VOLTS), the input signal is attenuated 60 dB (1000: 1 voltage division) by the resistive voltage divider consisting of R101, R103, and R104. Trimmer C102 is adjusted at 100 kHz, and R104 is adjusted at 400 Hz to provide constant attenuation over the input frequency range.

4-15. Impedance Converter Assembly A2

4-16. The impedance converter assembly utilizes a nuvistor tube cathode follower circuit to match the high output impedance of the input attenuator to the low input impedance of the second attenuator. The cathode follower circuit preserves the phase relationship of the input and output signals while maintaining a gain of unity. See impedance converter assembly schematic diagram illustrated on Figure 6-1.

4-17. The ac signal input to the impedance converter is RC coupled to the grid of cathode follower V201 through C201 and R203. The output signal is developed by Q201 which acts as a variable resistance in the cathode circuit of V201. The bootstrap feedback from the cathode of V201 to R203 increases the effective resistance of R203 to the input signal. This prevents R203 from loading the input signal and preserves the high input impedance of the Model 3400A. The gain compensating feedback from the plate of V201 to the base of Q201 compensates for any varying gain in V201 due to age or replacement.

4-18. Breakdown diode CR201 controls the grid bias voltage on V201 thereby establishing the operating point of this stage. CR202 and R211 across the base-emitter junction of Q201 protects Q201 in the event of a failure in the +75 volt power supply. Regulated dc is supplied to V201 filaments to avoid inducing ac hum in the signal path. This also prevents the gain of V201 changing with line voltage variations.

4-19. Second Attenuator Assembly A3

4-20. The second attenuator is a resistive divider which attenuates the ac input signal while maintaining a low impedance output for the following amplification stages. See second attenuator assembly schematic diagram illustrated in Figure 6-1.

4-21. The ac input signal is applied to a precision resistance voltage divider consisting of R302 through R312. These resistors are arranged to give six ranges of attenuation at 10 dB per range. The six ranges of the second attenuator combined with the two ranges of the input attenuator make up the 12 ranges of attenuation (0.001 to 300V). Trimmer capacitor C303 (10MHz 0.3V ADJ) provides an adjustment for frequency response at the higher frequencies.

4-22. Video Amplifier Assembly A4

4-23. The video amplifier functions to provide constant gain to the ac signal being measured over the entire frequency range of Model 3400A. See video amplifier assembly schematic diagram illustrated on Figure 6-2.

4-24. The ac input signal from the second attenuator is coupled through C402 to the base of input amplifier Q401. Q401, a class A amplifier, amplifies and inverts the signal which is then direct coupled to the base of bootstrap amplifier Q402. The output, taken from Q402 emitter is applied to the base of Q403 and fed back to the top of R406 as a bootstrap feedback. This positive ac feedback increases the effective ac resistance of R406 allowing a greater portion of the signal to be felt at the base of Q402. In this manner, the effective ac gain of Q401 is increased for the midband frequencies without disturbing the static operating voltages of Q401.

4-25. Driver amplifier Q403 further amplifies the ac signal and the output at Q403 collector is fed to the base circuit emitter follower Q404. The feedback path from the collector of Q403 to the base of Q402 through C405 (10 MHz ADJ) prevents spurious oscillations at high input frequencies. A dc feedback loop exists from the emitter circuit of Q403, to the base of Q401 through R425. This feedback stabilizes the Q401 bias voltage. Emitter follower Q404 acts as a driver for the output amplifier consisting of Q405 and Q406; a complimentary pair operating as a push-pull amplifier. The video amplifier output is taken from the collectors of the output amplifiers and applied to thermocouples TC401. A gain stabilizing feedback is developed in the emitter circuits of the output amplifiers. This negative feedback is applied to the emitter of input amplifier Q401 and establishes the overall gain of the video amplifier.

4-26. Trimmer capacitor C405 is adjusted at 10 MHz for frequency response of the video amplifier. Diodes CR402 and CR406 are protection diodes which prevent voltage surges from damaging transistors in the video amplifier. CR401, CR407, and CR408 are temperature compensating diodes to maintain the zero signal balance condition in the output amplifier over the operating temperature range. CR403, a breakdown diode, establishes the operating potentials for the output amplifier.

4-27. Chopper Op Amp Assembly A6 And Thermocouple Pair (Part Of A4)

4-28. The chopper op amp and thermocouple pair form a servo loop which functions to position the direct reading meter M1 to the rms value of the ac input signal. The chopper op amp and thermocouple pair schematic diagram is illustrated in Figure 6-3.

4-29. The video amplifier output signal is applied to the heater of thermocouple TC401. This ac voltage causes a dc voltage to be generated in the resistive portion of TC401 which is proportional to the heating effect (rms value) of the ac input. The dc voltage is applied to the chopper op amp.

4-30. The chopper op amp assembly consists of a chopper op amp (U601), filter, oscillator, and output amp (U602). The chopper op amp is a high gain low drift op amp and is used to modulate the applied dc voltage, amplify the voltage, and then demodulate the voltage back to dc (the output voltage of the amplifier). The output of the amplifier is the ac stabilizing and summing feedback for thermocouple TC402, and is also applied to the filter. The ac stabilizing feedback (using R614, R615, and C605) is used to prevent the circuitry from oscillating.

4-31. The oscillator consisting of Q601, Q602, and associated circuitry, is used to reduce the noise of the chopper op amp. It operates at a frequency of approximately 2KHz.

4-32. The output from the chopper op amp (summing feedback) is applied to the heating element of thermocouple TC402. The dc voltage developed in the resistive portion of TC402 is effectively subtracted from the voltage developed by TC401. The input signal to the chopper op amp then becomes the difference in the dc outputs of the two thermocouples. When the difference between the two thermocouples becomes zero, the dc output from the chopper op amp will be equal to the ac from the video amplifier.

4-33. The filter, consisting of R617, R618, R619, C607 and C608, is used to further reduce the noise on the output of the chopper op amp. This is to make the meter reading quiet.

4-34. The output of the filter is connected to the output amp (U602). The purpose of the amplifier is to drive the meter (M1) and to provide a low impedance output for the rear D.C. OUT connector. The output impedance of the amplifier is approximately 1 ohm. Since there

are two 499 ohm resistors (R624 and R631) between the amplifier output and the rear terminal, the output impedance at the terminal is approximately 1000 ohms.

4-35. Other circuits, consisting of C611, R629, and R630, are used to speed up the step response of the 3400A.

4-36. Power Supply Assembly A7

4-37. The power supply assembly provides dc operating voltages for the tube and transistors used in the Model 3400A. See power supply assembly schematic diagram illustrated on Figure 6-4.

4-38. Either 115 or 230 volts ac is connected to the primary of power transformer T1 through fuse F1 and the POWER switch S1. Switch S2 (slide switch on rear panel) connects T1 primary windings in series for 230-volt operation or in parallel for 115-volt operation. Neon lamp DS1 lights to indicate LINE power ON when ac power is applied and S1 is closed.

4-39. Regulator Operation

4-40. The series regulator acts as a dynamic variable resistor in series with the power supply output. A control amplifier senses changes in the output voltage by comparing the output with a fixed reference voltage. The control amplifier then supplies any output voltage changes to the driver transistor, which in turn changes the resistance of the series regulator to oppose the change in output voltage. Diodes CR704, CR713 and CR706 across the base emitter junction of the series regulator provide overload current protection.

4-41. +75 Volt Supply

4-42. The +75 volt supply consists of a full-wave rectifier (CR701 and CR702) whose output is filtered by C1A and C1B and regulated by series regulator Q1. The +75 volt supply provides regulated +75 volts which is used as the plate supply voltage for V201. Voltage variation from the output is felt at Q702 base circuit through C704, R715, and R716. The C703 and R709 network provides phase correction for power supply stability. The regulation circuitry is in the negative leg of the +75 volt supply, and uses the -17.5 volt supply as a reference.

4-43. -17.5 Volt Supply

4-44. The regulated -17.5 volt supply consists of a full-wave rectifier (CR711, and CR712) whose output is filtered by C706 and C707 and regulated by Q2. Breakdown diode CR715 provides reference voltage at the base of Q704. Regulation operation is the same described in Paragraph 4-40.

4-45. -6.3 Volt Supply

4-46. The regulated -6.3 volt supply consists of a full-wave rectifier (CR716 and CR717) whose output is filtered by C2 and regulated by Q3. Emitter follower Q705 is connected to the -17.5 volt supply which provides a reference for the -6.3 volt supply. Series regulator Q3 acts as a dynamic variable resistor in series with the output to oppose changes in output voltage.

WARNING

Maintenance described herein is performed with power supplied to the instrument, and protective covers removed. Such maintenance should be performed only by service-trained personnel who are aware of the hazards involved (for example, fire and electrical shock). Where maintenance can be performed without power applied, the power should be removed.

SECTION V

MAINTENANCE

5-1. INTRODUCTION

5-2. This section contains the information necessary for maintenance of the Model 3400A RMS Voltmeter. Included are performance checks, adjustment and calibration procedures, and troubleshooting procedures.

5-3. TEST EQUIPMENT

5-4. The test equipment required for the maintenance of the Model 3400A is listed in Table 5-1. If the recommended model is not available, use any substitute that meets the required characteristics.

5-5. PERFORMANCE CHECKS

5-6. The Performance Checks are in-cabinet tests that compare the Model 3400A with its given specifications. These checks may be used for incoming inspection, periodic maintenance, and for specification checks after a repair. A Performance Check Test Card is provided at the end of this section for recording the performance of the instrument during the Performance Checks. The card may be removed from the manual and used as a permanent record of the incoming inspection or of a routine performance check. If the instrument fails to meet any of its specifications, perform the Adjustment and Calibration Procedures outlined in Paragraph 5-15.

NOTE

Allow a 30-minute warmup period before making performance checks. During the performance checks, periodically vary the Model 3400A line voltage $\pm 10\%$ with a power line transformer to assure that the instrument operates correctly at various ac line voltages.

5-7. Accuracy, Linearity, And DC Output Check

5-8. The accuracy, linearity, and dc output test set-up is illustrated in Figure 5-1. A Meter Calibrator Fluke Model 760A and a Digital Multimeter -hp- Model 3468A are required for this test.

- a. Connect test setup illustrated in Figure 5-1.
- b. Set Model 3400A RANGE switch to 0.001 position.
- c. Adjust the Meter Calibrator for a 0.001V 400Hz ac volts output; set the Digital Multimeter to measure 1V dc.

d. If Model 3400A does not indicate within values listed under "meter reading" in Table 5-2, perform low frequency calibration procedure, Paragraph 5-21. Record 3400A readings.

e. DC output as indicated on the Digital Multimeter should be within values listed under "3400A DC output" in Table 5-2.

f. Continue to check accuracy, linearity, and dc output using Table 5-2.

Table 5-1. Required Test Equipment

| Instrument Type | Required Characteristics | Use | Recommended Model |
|----------------------------------|--|---|--|
| DC Digital Multimeter | Accuracy: $\pm 0.1\%$ full scale Voltage Range: 10mV to 100V | Performance Checks Adjustment and Calibration | -hp- Model 3468A |
| Meter Calibrator | Voltage Range: 1mV to 300 V rms Frequency: 400 Hz | Performance Checks Adjustment and Calibration Troubleshooting | Fluke Model 760A |
| Oscillator | Frequency Range: 10 Hz to 10 MHz Output: 1 mV to 3 V Frequency Response: 0.25% (expand scale) | Performance Checks Adjustment and Calibration Troubleshooting | -hp- Model 652A Test Oscillator |
| Oscilloscope | Sensitivity: .005V/cm Bandwidth: dc to 20 MHz | Troubleshooting | -hp- Model 1740A |
| Pulse Generator | Pulse Width: variable to 10 μ sec Pulse Amp: ± 10 volts peak, variable Pulse Rate: 250 to 1000 pps | Performance Checks | -hp- Model 214B |
| Frequency Counter | Range: 250 to 1000 Hz Accuracy: ± 1 count Time Interval: 1 μ sec | Performance Checks | -hp- Model 5381A |
| Peak Responding Voltmeter | Voltage Range: 0.5 V to 300 V Accuracy: $\pm 3\%$ full scale | Performance Checks | -hp- Model 410C Voltmeter |
| Average Responding Voltmeter | Voltage Range: 0.001 to 300 V Accuracy: 1% full scale | Adjustment and Calibration Troubleshooting | -hp- Model 400E/EL Voltmeter |
| Power Supply | Output Voltage: 5 V dc Output Current: 5 mA | Troubleshooting | -hp- Model 6214A |
| RMS Responding Voltmeter | Range: 1 m V full scale | Performance Checks | -hp- Model 3400A RMS Voltmeter |
| Resistor | 200 k Ω , metal film, $\frac{1}{4}$ W 1% | Performance Checks | -hp- Part No. 0757-0782 |
| Resistor | 499 k Ω , metal film, $\frac{1}{4}$ W 1% | Troubleshooting | -hp- Part No. 0757-0327 |
| Resistor | 1k Ω , Carbon, $\frac{1}{4}$ W 10% | Troubleshooting | -hp- Part No. 0684-1021 |
| 50 Ω Feedthru Termination | Resistor: fixed comp 50 Ω $\pm 5\%$ $\frac{1}{4}$ W | Performance Checks | -hp- Model 11048B 50 Ω Feedthru |
| BNC-T-Adapter | -- | Performance Checks Adjustment and Calibration | -hp- Part No. 1250-0072 |
| Adapter | 410C to Dual Banana | Performance Checks | -hp- Model 11018A |
| Extender Board | 15 pin programmable | Troubleshooting | -hp- Part No. 6038 |

Table 5-2. Accuracy, Linearity, and DC Output Check Data

| Voltmeter Calibrator Output (V) | 3400A Voltage Range (V) | 3400A Meter Reading (V) | 3400A DC Output (V) |
|---------------------------------|-------------------------|-------------------------|---------------------|
| 0.001 | 0.001 | 0.000990 to 0.00101 | 0.992 to 1.008 |
| 0.003 | 0.003 | 0.00297 to 0.00303 | 0.942 to 0.957 |
| 0.01 | 0.01 | 0.00990 to 0.0101 | 0.992 to 1.008 |
| 0.03 | 0.03 | 0.0297 to 0.0303 | 0.942 to 0.957 |
| 0.1 | 0.1 | 0.0990 to 0.101 | 0.992 to 1.008 |
| 0.3 | 0.3 | 0.297 to 0.303 | 0.942 to 0.957 |
| 1.0 | 1.0 | 0.990 to 1.01 | 0.992 to 1.008 |
| 0.9 | 1.0 | 0.89 to 0.91 | 0.892 to 0.908 |
| 0.8 | 1.0 | 0.79 to 0.81 | 0.792 to 0.808 |
| 0.7 | 1.0 | 0.69 to 0.71 | 0.692 to 0.708 |
| 0.6 | 1.0 | 0.59 to 0.61 | 0.592 to 0.608 |
| 0.5 | 1.0 | 0.49 to 0.51 | 0.492 to 0.508 |
| 0.4 | 1.0 | 0.39 to 0.41 | 0.392 to 0.408 |
| 0.3 | 1.0 | 0.29 to 0.31 | 0.292 to 0.308 |
| 0.2 | 1.0 | 0.19 to 0.21 | 0.192 to 0.208 |
| 0.1 | 1.0 | 0.090 to 0.11 | 0.092 to 0.108 |
| 3.0 | 3.0 | 2.97 to 3.03 | 0.942 to 0.957 |
| 10.0 | 10.0 | 9.90 to 10.10 | 0.992 to 1.008 |
| 30.0 | 30.0 | 29.7 to 30.3 | 0.942 to 0.957 |
| 100.0 | 100.0 | 99.0 to 101.0 | 0.992 to 1.008 |
| 300.0 | 300.0 | 297.0 to 303.0 | 0.942 to 0.957 |

use 9313
Rms Voltmeter
to set up proper
voltages

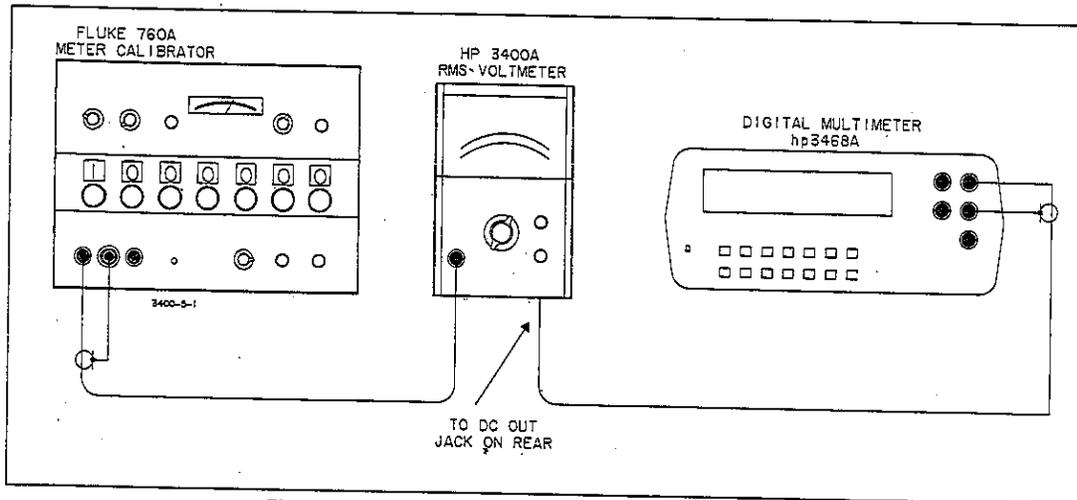


Figure 5-1. Accuracy, Linearity, and DC Output Test Setup

5-9. Frequency Response Check

NOTE

Connect 50 Ω feedthru termination directly to 3400A INPUT to eliminate loss in output cable at high frequency.

- a. Connect test setup illustrated in Figure 5-2.
- b. Set Model 3400A RANGE switch and Test Oscillator output attenuator to 1 volt position.
- c. Set Test Oscillator for 400 Hz output and adjust output amplitude for the reading obtained in Paragraph 5-8 step d on the Model 3400A.
- d. Switch the Test Oscillator monitor switch to expand mode and set a convenient reference level.
- e. Adjust test oscillator output frequency to values listed under "frequency" in Table 5-3; adjust oscillator output voltage to maintain reference level set in step d. If Model 3400A does not indicate within values under "meter reading" in Table 5-3, perform high frequency calibration procedures, Paragraph 5-25.

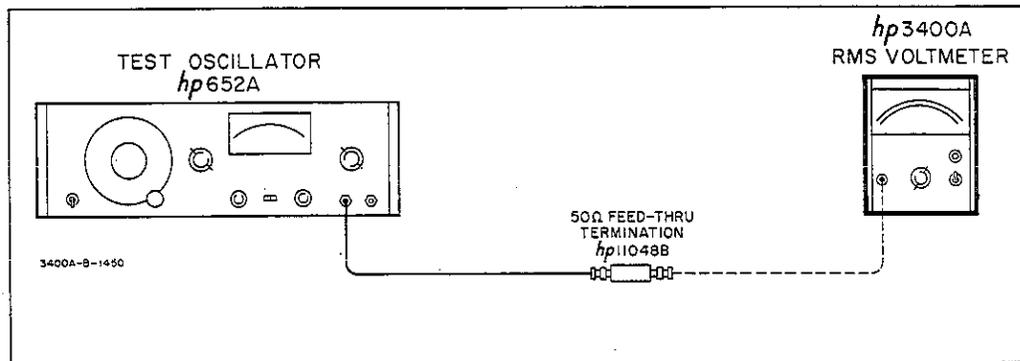


Figure 5-2. Frequency Response Test Setup

Table 5-3. Frequency Response Check

| Frequency | Meter Reading |
|-----------|---------------|
| 15 Hz | 0.95 to 1.05 |
| 45 Hz | 0.95 to 1.05 |
| 100 Hz | 0.99 to 1.01 |
| 900 kHz | 0.99 to 1.01 |
| 1.2 MHz | 0.98 to 1.02 |
| 1.8 MHz | 0.98 to 1.02 |
| 2.2 MHz | 0.97 to 1.03 |
| 2.8 MHz | 0.97 to 1.03 |
| 3.2 MHz | 0.95 to 1.05 |
| 9.8 MHz | 0.95 to 1.05 |

5-10. Input Impedance Check**5-11. Resistance Check**

- a. Connect the Test Oscillator, 50 ohm feedthru and -hp- Model 3400A to position A in Figure 5-3.
- b. Set 3400A to 1 volt range and Test Oscillator to 400 Hz.
- c. Adjust Test Oscillator output for 1 volt indication on Model 3400A.
- d. Connect Model 3400A to position B, as shown in Figure 5-3. The 3400A meter reading now should change less than or equal to .02 volts (2 minor divisions). 2 minor divisions corresponds to an input impedance of 10 megohms.

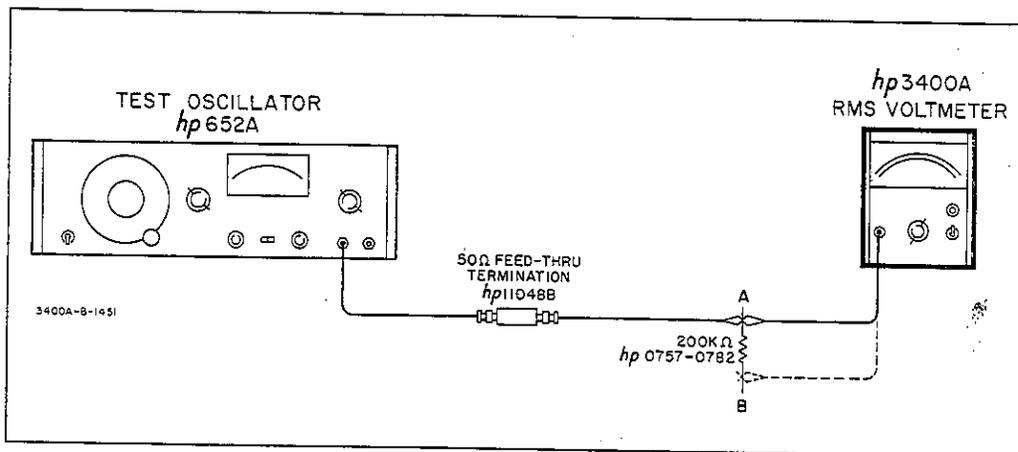


Figure 5-3. Input Impedance Test Setup

5-12. Capacitance Check

- a. Connect Test Oscillator, 50 ohm feedthru and Model 3400A to position B in Figure 5-3. Insert the resistor lead directly into the BNC connector on the 3400A as an adapter adds capacitances to the measurement.
- b. Set 3400A to 0.001 volt range and Test Oscillator to 400 Hz.
- c. Adjust Test Oscillator output for full scale indication on Model 3400A. Switch the Test Oscillator Switch to Expand mode and set a convenient reference level.
- d. Change Test Oscillator frequency to 16 kHz, maintaining the reference level set in step c. The Model 3400A reading should be greater than 0.707mV. This corresponds to an input shunt capacity of less than 50 pF.
- e. Set Model 3400A Range switch to 1 V position and repeat step c.
- f. Change Test Oscillator frequency to 40 kHz, maintaining the reference level set in step c. The Model 3400A reading should be greater than .707V. This corresponds to an input shunt capacity of less than 20 pF.

5-13. Crest Factor Check

- a. Connect test setup as illustrated in Figure 5-4.
- b. Set Model 3400A Range switch to 1 volt position.
- c. Adjust Pulse Generator for pulse output with the following characteristics:

Pulse Rate - 990 pps as indicated on electronic counter.

Pulse Width - 10 μ sec as indicated on electronic counter in time interval mode.

Pulse Amplitude - 7.07 volts as indicated on Model 410C.

NOTE

The 410C responds to the positive peak above the average of the input waveform. Since the Model 410C is calibrated to read the rms value of a sine wave a correction factor is required to measure pulse amplitude. The correction factor under these conditions is:

$$E_{410C} = \frac{E_{pp}}{\sqrt{2} \left(1 + \frac{T_1}{T_2} \right)}$$

see waveform

$$E_p = \frac{T_2}{T_1 + T_2}$$

$$E_{410C} = \sqrt{2} \left(1 + \frac{T_1}{T_2} \right)$$

$$E_{410C} = 7.07V$$

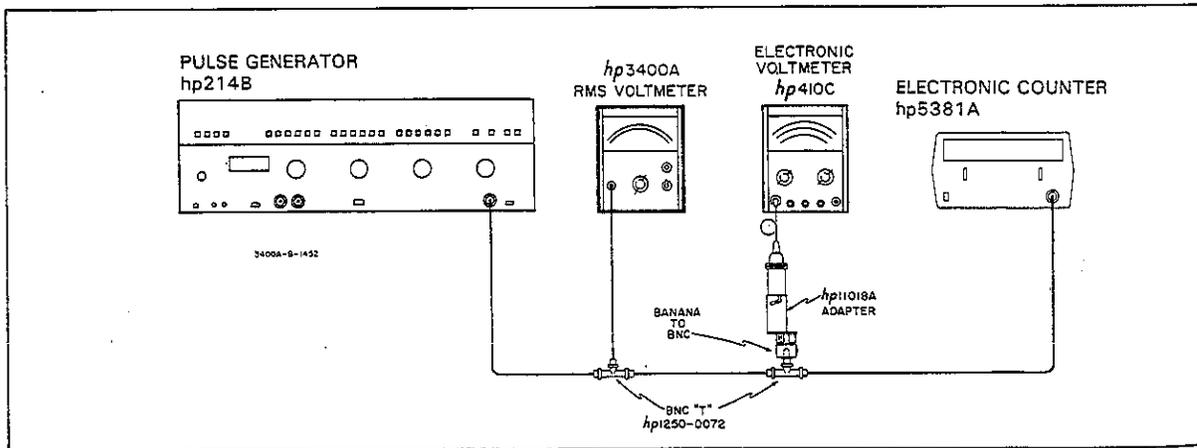
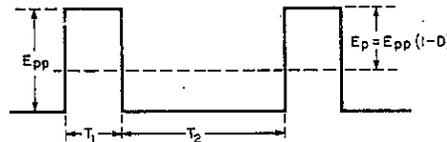


Figure 5-4. Crest Factor Test Setup

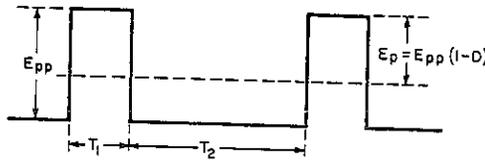
This corresponds to a crest factor of 10 where:

$$E_{rms} = E_{pp} \sqrt{D(1-D)} \text{ where } D = \frac{T_1}{T_1 + T_2}$$

$$C.F. = \frac{E_p}{E_{rms}}$$

$$C.F. = \frac{E_{pp}(1-D)}{E_{pp} \sqrt{D(1-D)}}$$

$$C.F. = \sqrt{\frac{1-D}{D}}$$



- d. The Model 3400A should indicate 1 volt, $\pm 4\%$ (includes the $\pm 3\%$ accuracy of 410C).
- e. Adjust pulse generator pulse rate to 250 pps as indicated on electronic counter. This corresponds to a crest factor of 20.
- f. Model 3400A should indicate 0.5 volt, $\pm 4\%$ (includes the $\pm 3\%$ accuracy of 410C.)

5-14. Output Noise Check

- a. Connect 50 ohm feedthru to 3400A INPUT.
- b. Connect another RMS Voltmeter to DC output.
- c. Set -hp- Model 3400A to 0.001 volt range.
- d. The reading on the RMS Voltmeter should not exceed 1 mV.

5-15. ADJUSTMENT AND CALIBRATION PROCEDURES

5-16. The following is a complete adjustment and calibration procedure for the Model 3400A. These procedures should be conducted only if it has previously been established by Performance Checks, Paragraph 5-5 to 5-14, that the Model 3400A is out of adjustment. Indiscriminate adjustment of the internal controls to refine settings may actually cause more difficulty. If the procedures outlined do not rectify any maladjustments that may exist, and you have carefully rechecked your connections and settings, refer to Paragraph 5-29, Troubleshooting Procedures for possible cause and recommended corrective action.

5-17. Mechanical Meter Zero

5-18. The mechanical meter zero screw is located on the instrument front panel. If the meter pointer does not indicate zero when the instrument power has been off for at least one minute, mechanically zero the meter following the procedure outlined below.

- a. Turn instrument power off; disconnect input signal and any cable connected to J2 (DC OUT) at rear of instrument and allow one minute for meter pointer to stabilize.

b. Rotate zero adjust CW until pointer is to left of zero, moving up scale. Continue until pointer is at zero. If pointer overshoots zero, repeat operation.

c. When the pointer is exactly at zero, rotate the adjusting screw slightly counterclockwise to remove tension on pointer suspension. If the meter pointer moves to the left during this adjustment, repeat steps b and c.

5-19. Power Supply Checks

5-20. Power supply voltage and ac ripple tolerances are listed in Table 5-4. Test points are also indicated in this table. When making ripple voltage measurements, it may be desirable to use a battery powered A.C. Voltmeter (H-P 403B) to avoid any undesirable ground loop currents.

5-21. Low Frequency Calibration

5-22. Amplifier Offset Adjustment

a. Perform the following adjustment only for Revision C A6 assemblies. The adjustment is not required for Revision A assemblies.

b. Remove the 3400A's top cover.

c. Refer to the Chopper Amplifier component locator (see Page 6-7/6-8) and connect TP5 to TP1 (on the A6 assembly).

d. Connect a DC Voltmeter between TP6 and TP1.

e. Adjust A6R629 (on the A6 assembly) for a $\approx 2\text{mV}$ dc reading on the dc voltmeter.

5-23. Amplifier Gain Adjustment

a. Connect test setup illustrated in Figure 5-1.

b. Set Model 3400A RANGE switch to 0.01 volt position.

c. Adjust the Meter Calibrator for a 0.01V 400Hz ac volts output; set the Digital Multimeter to measure 1V dc.

d. Remove the 3400A's top cover; adjust A6R627 (on the A6 assembly) for 1.0V as indicated on the Digital Multimeter.

e. Adjust R6 (FULL-SCALE ADJUST) for Model 3400A full-scale meter indication.

5-24. 1/10 Scale Adjustment

a. Connect test setup illustrated in Figure 5-1; omit the DC Voltmeter.

b. Set Model 3400A RANGE switch to 0.1 volt position and adjust Voltmeter Calibrator for 0.01 volt rms, 400 Hz output.

NOTE

The meter may show a small positive offset when the 3400A's input is shorted. This is normal and the 3400A will be fully accurate from 1/10 scale to full scale.

- c. Adjust the 1/10 scale adjust (A6R626, located on the A6 assembly) until the meter of the 3400A reads exactly 1/10 scale (0.1V).

Table 5-4. Power Supply Checks

| Power Supply | Test Equipment And Check Point | DC Voltage Specifications | Regulation (Vary Line Voltage Between 103.5 and 126.5 vac) | Ripple Specifications |
|--------------|--|---------------------------|--|-------------------------------|
| - 17.5 Vdc | Connect Digital Multimeter, Oscilloscope between violet lead on video amplifier (A4) board and chassis ground. | - 16.8 to 18.2 Vdc | ± 0.5 volt from nominal reading at 115 Vac line. | 400 μ V rms or 1.1 mV p-p |
| + 75 Vdc | Connect Digital Multimeter, Oscilloscope between red/wht/blue on video amplifier A4 and chassis ground. | 70.0 to 78.0 Vdc | ± 1 volt from nominal reading at 115 Vac line. | 400 μ V rms or 1.1 mV p-p |
| - 6.3 Vdc | Connect Digital Multimeter, Oscilloscope between Q3 emitter (grey lead) and chassis ground. | - 5.9 to -6.5 Vdc | ± 0.1 volt from nominal reading at 115 Vac line. | 750 μ V rms or 2.0 mV p-p |

5-25. 1 Volt Adjustment

- Connect test setup illustrated in Figure 5-1; omit the DC Voltmeter.
- Set Model 3400A RANGE switch to 1 volt position.
- Adjust voltmeter calibrator for 1.0 volt rms, 400 Hz output.
- Remove right side cover (INPUT side) and adjust R104 (1 V ADJUST) for Model 3400A full-scale meter indication.

5-26. High Frequency Calibration

5-27. Amplifier Gain Adjustment

NOTE

The Test Oscillator used in this procedure should be calibrated at the end of its output cable.

- a. Connect test setup illustrated in Figure 5-2.
- b. Set Model 3400A RANGE switch and Test Oscillator output attenuator to 0.001V position.
- c. Adjust Test Oscillator output frequency for 400 Hz; output voltage for 90% of full scale as indicated on Model 3400A meter.
- d. Switch the Test oscillator monitor switch to expand mode and set a convenient reference level.
- e. Change Test Oscillator frequency to 10 MHz. Adjust Test Oscillator output voltage to maintain reference level set in step d.
- f. Adjust C405 (10 MHz ADJUST) on A4 board for 90% full scale as indicated on the Model 3400A meter. Replace right side cover; readjust C405 if meter reading varies after replacing the cover.
- g. Vary oscillator between 3 and 10 MHz; maintaining reference level set in step d. If the Model 3400A meter reading varies below 85% or above 95% of full scale, repeat step f until optimum response is obtained between 3 and 10 MHz.

5-28. Input Attenuator Adjustment

NOTE

The Test Oscillator used in this procedure should be calibrated at the end of its output cable.

- a. Connect test setup illustrated in Figure 5-2.
- b. Set Model 3400A RANGE switch and Test Oscillator output attenuator to 1 volt position.
- c. Adjust Test Oscillator output frequency for 400 Hz, output voltage for 90% full scale as indicated on Model 3400A meter.
- d. Switch the Test Oscillator monitor switch to expand mode and set a convenient reference level.
- e. Change Test Oscillator frequency to 100 kHz; adjust Test Oscillator output voltage to maintain reference level set in step d.
- f. Remove Model 3400A bottom cover. Adjust C102 (1V, 100 KC ADJ) for 90% full scale as indicated on Model 3400A meter.
- g. Vary oscillator between 100 kHz and 10 MHz; maintain test oscillator output voltage to reference level set in step d. If Model 3400A meter reading varies more than $\pm 1\%$ to 1 MHz, $\pm 2\%$ from 1 MHz to 2 MHz, $\pm 3\%$ from 2 MHz to 3 MHz, or $\pm 5\%$ from 3 MHz to 10 MHz, readjust C102 until optimum response is obtained.

5-29. Second Attenuator Adjustment**NOTE**

The Test Oscillator used in this procedure should be calibrated at the end of its output cable.

- a. Connect test setup illustrated in Figure 5-2.
- b. Set Model 3400A RANGE switch and Test Oscillator output attenuator to a 0.3 volt position.
- c. Adjust Test Oscillator output frequency for 400 Hz; output voltage for 90% full scale as indicated on Model 3400A meter.
- d. Switch the Test Oscillator monitor switch to expand mode and set a convenient reference level.
- e. Change Test Oscillator output frequency to 3 MHz; adjust output voltage to maintain reference level set in step d.
- f. Adjust C303 (10 MC .3V ADJ) for 90% full scale as indicated on Model 3400A meter.
- g. Vary Test Oscillator between 3 MHz and 10 MHz; maintain test oscillator output voltage to reference level set in step d. If Model 3400A meter reading varies below 85% or above 95% of full scale, repeat steps e and f until optimum response is obtained between 3 and 10 MHz.

5-30. TROUBLESHOOTING PROCEDURES

5-31. This section contains procedures designed to assist in the isolation of malfunctions. These operations should be undertaken only after it has been established that the difficulty cannot be eliminated by the Adjustment and Calibration Procedures, Paragraph 5-15. An investigation should also be made to ensure that the trouble is not a result of conditions external to the Model 3400A.

5-32. Conduct a visual check of the Model 3400A for possible burned or loose components, loose connections, or any other condition which might suggest a source of trouble.

5-33. Table 5-5 contains a summary of known problems by front panel symptoms.

5-34. Table 5-6 contains procedures which may be used as a guide in isolating malfunctions. The checks outlined in Table 5-6 are not designed to measure all circuit parameters, rather only to localize the malfunction. Therefore, it is quite possible that additional measurements will be required to completely isolate the problem. Amplifier gain and biasing may vary slightly from instrument to instrument; therefore, it should not be necessary to precisely duplicate waveforms or values described.

NOTE

Do not use an extender board on the Chopper Amplifier Board (A6).

Table 5-5. Front Panel Symptoms

| Symptoms | Possible Causes |
|---|---|
| Reading far out of tolerance, meter pegged out. | Check for a defective oscillator on the A6 assembly. |
| Excessive offset (> 8%) with input shorted. | A6R626 and/or C405 misadjusted. |
| 400Hz calibration low and frequency response falls off above 50KHz. | Q401 or Q402 shorted. |
| Switching transients exceeds 5% of full scale with shorted input. | Check collector voltage of Q201 (should not exceed 9.0V) |
| Instrument has been overloaded. | Check Q201, Q401, Q402, and TC401. See paragraph 5-34 for details on TC401. |
| Meter jitter. | Noisy chopper op amp (U601). |
| Full-scale difference from range to range. | Check resistors in second attenuator. |
| Meter pegs full scale. | Check thermocouples. See paragraph 5-34 for details. |
| Overshoot, undershoot, or sluggish response on meter. | Replace thermocouples. See paragraph 5-37. |
| Meter moves rapidly from zero to full-scale and back. | Check ac feedback on the A6 assembly (R614, C605, and R615). |

5-35. Checking Thermocouples TC401 and TC402

5-36. The following procedure will allow you to check the thermocouples for proper operation in the -hp- Model 3400A RMS Voltmeter.

NOTE

This check will not yield any information concerning thermocouple operation for either sluggish or overshoot-undershoot response on 3400A meter. If a 3400A has the above symptoms replace thermocouples.

5-37. To perform these checks, supply 5mA of current to the heaters of the thermocouples. This can be accomplished by connecting a 1K ohm resistor (-hp- Part Number: 0684-1021) in series with the output of a 5V dc power supply. Then connect the supply to the heater of thermocouple and measure the output voltage of the thermocouple with the Digital Multimeter. If the thermocouple fails any of the following tests, replace it using the procedure in paragraph 5-37. Do the following:

- a. Turn the 3400A off and remove the A6 assembly.

NOTE

See Figure 6-3 for component locations.

- b. Set the multimeter to the ohms function. Connect the test leads between ground and the junction of C413 and C415 on the A4 assembly (this checks the resistance of the heater

in TC401). Make sure the reading on the multimeter is between 76.5 ohms and 103.5 ohms. If the reading is not within limits, replace the matched set of thermocouples (-hp- Part Number: 0853-0003).

c. Remove the multimeter and, in place of the multimeter, connect the 5V dc power supply between ground and the junction of C413 and C415. Turn the power supply on. Set the multimeter to the dc volts function and connect it as follows:

Negative (low) input to pin 11 on the A6 socket.

Positive (high) input to pin 13 on the A6 socket.

The multimeter should display between +6.5mV and +9mV. Note the reading on the multimeter. If the reading is not within limits, replace the thermocouple pair. If the reading is within the test limits, remove the multimeter and set it to the ohms function. Then disconnect the power supply and turn it off.

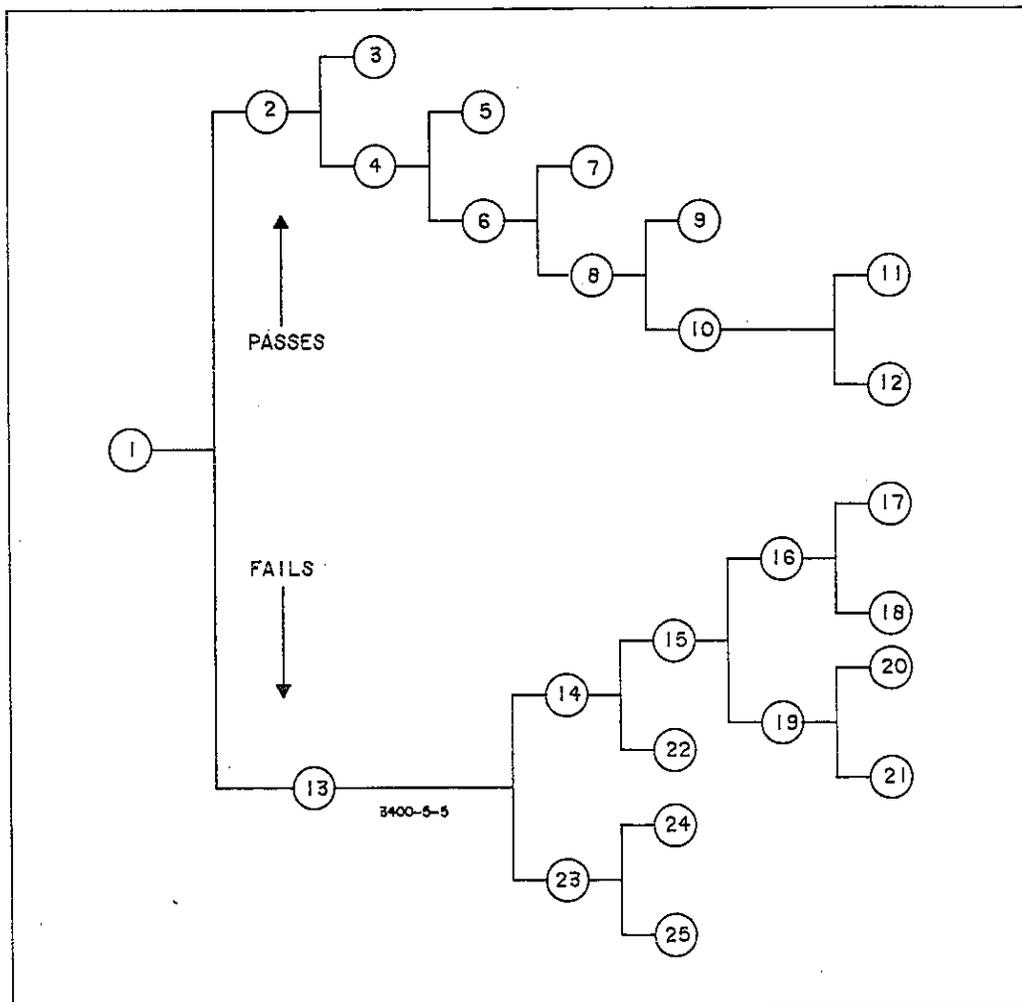


Figure 5-5. Troubleshooting Tree

Table 5-6. Troubleshooting Procedure

| Check | Procedure | Action | Check | Procedure | Action |
|-------|--|---|-------|---|---|
| ① | Set the 3400A to the 1V range. Apply 1V, 400Hz ac signal to the input terminals. Measure the signal at junction of C413 and 415. The reading should be between 240mV and 280mV RMS. | PASSES: Proceed to ② FAILS: Proceed to ⑬ | ⑪ | Check for a defective U602. | |
| ② | Measure the signal between TP2 and TP1 on the A6 assembly. The signal should look like the one in Figure 5-6. | PASSES: Proceed to ④ FAILS: Proceed to ③ | ⑫ | The A6 assembly is probably working correctly. Make sure the meter assembly M1 and associated circuitry are good. | |
| ③ | Troubleshoot and repair oscillator circuitry. | | ⑬ | Measure the ac signal at the output of impedance converter A2 (negative side of C205). The reading should be approximately .96mV RMS. | PASSES: Proceed to ⑭ FAILS: Proceed to ⑰ |
| ④ | Turn the 3400A off and place the A6 board on an extender board. Unsolder and lift one end of R616 from the board (the dc feedback is now disconnected). Set the instrument to the 1V range and apply a 1V, 400Hz RMS ac signal to the input terminals. Using a Digital Multimeter (like the 3468A), measure the voltage between TP3 and TP1 on the A6 assembly. The voltage should be approximately 2mV to 2.5mV ac. | PASSES: Proceed to ⑧ FAILS: Proceed to ⑤ | ⑭ | Measure the ac signal at the input of the video amplifier A4 (positive side of C402). The reading should be approximately .95mV RMS. | PASSES: Proceed to ⑮ FAILS: Proceed to ⑳ |
| ⑤ | Check for a defective TC401. TC401 may also be disconnected from the output of the video amplifier via capacitors C413 and C415. | | ⑮ | Measure the ac signal at the base of Q404. The reading should be approximately 155mV RMS. | PASSES: Proceed to ⑯ FAILS: Proceed to ⑰ |
| ⑥ | Turn the instrument off and replace and resolder R616 on the A6 board. Make sure the 3400A is still on the 1V range and the 1V, 400Hz signal is still applied. Turn the instrument on and measure the voltage between TP4 and TP1 on the A6 board. The voltage should approximately be -4V dc. | PASSES: Proceed to ⑧ FAILS: Proceed to ⑦ | ⑯ | Measure the ac signal at the negative side C427. The reading should be approximately 32mV RMS. | PASSES: Proceed to ⑰ FAILS: Proceed to ⑱ |
| ⑦ | If the voltage is positive, check for a shorted CR603. If the voltage is negative but other than -4V, U602 or TC401 may be defective. | | ⑰ | Check for a defective C413 and C415. | |
| ⑧ | Check the voltage between TP5 and TP1 and make sure it is -.19V. | PASSES: Proceed to ⑩ FAILS: Proceed to ⑨ | ⑱ | Check for defective Q404, Q405, Q406 and associated circuitry. Also check the thermocouples (see paragraph 5-34). | |
| ⑨ | Troubleshoot the filter circuitry consisting of R617 through R619, and C606 through C608. | | ⑲ | Measure the ac signal at the emitter of Q402. Reading should be 1.85mV RMS. | PASSES: Proceed to ⑳ FAILS: Proceed to ㉑ |
| ⑩ | Check the voltage between TP6 and TP1 and make sure it is approximately -1V. | PASSES: Proceed to ⑫ FAILS: Proceed to ⑪ | ㉑ | Check Q401 and Q402 circuitry. | |
| | | | ㉒ | Check Q403 circuitry. | |
| | | | ㉓ | Check second attenuator circuitry A3. | |
| | | | ㉔ | Measure the ac signal at the input to impedance converter, pin 7 on A2 board. The reading should be approximately 1mV RMS. | PASSES: Proceed to ㉔ FAILS: Proceed to ㉕ |
| | | | ㉕ | Check the impedance converter or power supply. See Table 5-4 for specifications on power supply. | |
| | | | ㉖ | Check the input attenuator circuitry. | |

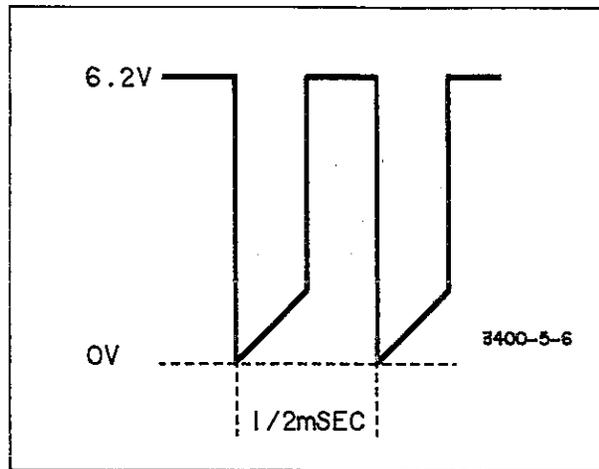


Figure 5-6. Input to Demodulator

d. Connect the multimeter between the silver colored wire on R4 (CAL pot on chassis) and pin 14 on the A6 socket (this step checks the heater of TC402). Make sure the reading is between 76.5 ohms and 103.5 ohms.

e. Remove the multimeter and, in place of the multimeter, connect the 5V dc power supply between the silver wire and pin 14 on the A6 socket (see previous step). Turn the power supply on. Set the multimeter to the dc volts function and connect it to pin 11 and pin 13 on the A6 socket (see step c). Make sure the displayed reading on the multimeter is negative and within 1mV of the reading noted in step c.

f. Disconnect the power supply and the multimeter from the 3400A. Set the multimeter to the ohms function and connect it between pin 11 and pin 14 of the A6 socket (this checks for thermocouples shorted to ground through the cover). Make sure the displayed reading on the multimeter is >200K ohms. If below 200K ohms, look for ground short.

5-38. Thermocouple Replacement

CAUTION

Exercise extreme care when removing or replacing the amplifier printed circuit board assembly and when shaping the thermocouple leads.

5-39. Should a thermocouple be defective, it is necessary to replace both as a matched pair (see Section VII, Table of Replaceable Parts) for part number. To replace thermocouples, perform the following steps:

- a. Turn instrument power off and remove right side (INPUT side) and top covers.
- b. Remove the four lead connection to the A4 amplifier board.
 1. Black coaxial cable (two leads)
 2. Violet lead
 3. White lead/blue lead.

- c. Remove the three mounting screws on the amplifier board.
- d. Gently pull bottom of board out at the same time relieving stress on thermocouple cable until the board will drop down and the top will clear main frame. Carefully fold board down to expose the four nuts holding the thermocouple shield.
- e. Remove four shield nuts; lift shield off. Remove thermocouples, noting orientation.
- f. Leads on new thermocouples must be shaped before inserting into PC board. During the shaping process, hold leads between bending point and glass with long-nose pliers.
- g. Place the red dots on the thermocouples face down on the A4 Video Amplifier Board. If one of the thermocouples has an additional colored dot place it in the TC402 position.
- h. Carefully insert new thermocouple leads and solder.
- i. Reverse steps e, d, c, b. Note: the violet lead goes to the lower of the two top connectors on the A4 board.
- j. After thermocouple replacements perform a complete adjustment and calibration procedure as outlined in Paragraph 5-15.

5-40. SERVICING ETCHED CIRCUIT BOARDS

5-41. The -hp- Model 3400A has five etched circuit boards. Use caution when removing them to avoid damaging mounted components. The assembly and -hp- Part No. are silk screened on the interior of the circuit board to identify it. Refer to Section VII for parts replacement and -hp- part number information.

5-42. The etched circuit boards are plated-through type. The electrical connection between sides of the board is made by a layer of metal plated through the component holes. When working on these boards, observe the following general rules:

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

Table 5-7. Factory Selected Components

| Designator | Function | Low | Value Normal | High |
|------------|---|------|---------------------------|-------|
| C205 | Adjust low frequency (10 Hz) response. | — | 100 μ F (selected) | — |
| C302 | Adjust high frequency (10 MHz) of Second Attenuator on 0.001 V and 1 V ranges. | 5 pF | 12 pF | 15 pF |
| C304 | Adjust high frequency (3 MHz to 10 MHz) of Second Attenuator on 0.3 V and 300 V ranges. | — | 24 pF | 39 pF |
| C305 | Adjust high frequency (10 MHz) of Second Attenuator on 0.01 V and 10 V ranges. | — | 5 pF | 12 pF |
| C427 | See NOTE on schematic. | — | 200 μ F (selected) | — |
| R419 | Adjust voltage at collector of Q406 (with no signal input) to 1.5V to 2.5V dc. | 270 | 300 | — |

b. Circuit components can be removed by replacing the soldering iron on the component lead on either side of the board and pulling upon lead. If a component is obviously damaged, clip leads as close to component as possible and then remove. Excess heat can cause the circuit and board to separate or cause damage to the component.

c. Component lead hole should be cleaned before inserting new lead.

d. To replace components, shape new leads and insert them in holes. Reheat with iron and add solder as required to insure a good electrical connection.

e. Clean excess flux from the connection and adjoining area.

5-43. A6 ASSEMBLY (03400-66512) RETROFIT PROCEDURE

5-44. The following procedure can be used to retrofit older 3400A's which have the old A6 Assembly (-hp- Part Number: 03400-66508) with the presently available A6 Assembly (-hp- Part Number: 03400-66512). To do the procedure, obtain a manual which has the schematic (in Figure 6-3) for the old A6 Assembly (Part Number 03400-66508). A manual with -hp- Part Number 03400-90008 and below is a good choice. Do the following:

a. Turn the 3400A off and disconnect it from the ac power source.

b. Refer to Figure 6-3 (of old A6 Assembly schematic) and remove R3, R8, R9 and R10. These parts and the part in the next step are located next to the connector of the A6 Assembly.

c. Refer to Figure 6-3. Connect and solder both legs of R4 together or connect pin 10 of the A6 Assembly to the CLR line of the thermocouple TC402.

d. Refer to Figure 6-4 (A10 Assembly schematic; Power Supply) and remove CR719, C711, C712, CR718, R701, R702, R712, R713, and Q706.

e. Remove the old A6 Assembly (03400-66508) and replace it with the new A6 Assembly (03400-66512).

f. Connect the 3400A to the ac power source and turn it on. After the recommended warmup, calibrate the instrument using the calibration procedure in paragraph 5-15.

g. After calibration, the 3400A may display an offset with OV inputs. This is normal and the 3400A will be fully accurate from 1/10 scale to full scale.

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 3400A
RMS Voltmeter
Serial No. _____

Tests performed by _____
Date _____

| Description | | Check | |
|---|--------------------|--------------------------------------|----------------------|
| Accuracy, Linearity and DC Output: | | | |
| Calibrator Output | 3400A Range | Meter Reading | DC Output |
| 0.001 | 0.001 | 0.000990 _____ 0.00101 | 0.992 _____ 1.008 |
| 0.003 | 0.003 | 0.00297 _____ 0.00303 | 0.942 _____ 0.957 |
| 0.01 | 0.01 | 0.00990 _____ 0.0101 | 0.992 _____ 1.008 |
| 0.03 | 0.03 | 0.0297 _____ 0.0303 | 0.942 _____ 0.957 |
| 0.1 | 0.1 | 0.0990 _____ 0.101 | 0.992 _____ 1.008 |
| 0.3 | 0.3 | 0.297 _____ 0.303 | 0.942 _____ 0.957 |
| 1.0 | 1.0 | 0.990 _____ 1.01 | 0.992 _____ 1.008 |
| 0.9 | 1.0 | 0.90 _____ 0.91 | 0.892 _____ 0.908 |
| 0.8 | 1.0 | 0.79 _____ 0.81 | 0.792 _____ 0.808 |
| 0.7 | 1.0 | 0.69 _____ 0.71 | 0.692 _____ 0.708 |
| 0.6 | 1.0 | 0.59 _____ 0.61 | 0.592 _____ 0.608 |
| 0.5 | 1.0 | 0.49 _____ 0.51 | 0.492 _____ 0.508 |
| 0.4 | 1.0 | 0.39 _____ 0.41 | 0.392 _____ 0.408 |
| 0.3 | 1.0 | 0.29 _____ 0.31 | 0.292 _____ 0.308 |
| 0.2 | 1.0 | 0.19 _____ 0.21 | 0.192 _____ 0.208 |
| 0.1 | 1.0 | 0.090 _____ 0.11 | 0.092 _____ 0.108 |
| 3.0 | 3.0 | 2.97 _____ 3.03 | 0.942 _____ 0.957 |
| 10.0 | 10.0 | 9.90 _____ 10.10 | 0.992 _____ 1.008 |
| 30.0 | 30.0 | 29.7 _____ 30.3 | 0.942 _____ 0.957 |
| 100.0 | 100.0 | 99.0 _____ 101.0 | 0.992 _____ 1.008 |
| 300.0 | 300.0 | 297.0 _____ 303.0 | 0.942 _____ 0.957 |
| Frequency Response Check: | | Frequency | Meter Reading |
| | | 15 Hz | 0.95 _____ 1.05 |
| | | 45 Hz | 0.95 _____ 1.05 |
| | | 100 Hz | 0.99 _____ 1.01 |
| | | 900 kHz | 0.99 _____ 1.01 |
| | | 1.2 MHz | 0.98 _____ 1.02 |
| | | 1.8 MHz | 0.98 _____ 1.02 |
| | | 2.2 MHz | 0.97 _____ 1.03 |
| | | 2.8 MHz | 0.97 _____ 1.03 |
| | | 3.2 MHz | 0.95 _____ 1.05 |
| | | 9.8 MHz | 0.95 _____ 1.05 |
| Input Impedance Check: | | | |
| Resistance | | _____ 10 MΩ or greater | |
| Capacitance | | _____ 50 pF or less 0.001 V to 0.3 V | |
| | | _____ 20 pF or less 1 V to 300 V | |
| Crest Factor Check: | | | |
| | | _____ 10:1 full scale | |
| | | _____ 20:1 half scale | |
| Output Noise Check: | | | |
| | | _____ 1 mV RMS or less | |

SECTION VI

CIRCUIT DIAGRAMS

6-1. INTRODUCTION

6-2. This section contains the circuit diagrams necessary for the operation and maintenance of the Model 3400A RMS Voltmeter. Included are schematic and parts location diagrams.

6-3. SCHEMATIC DIAGRAMS

6-4. The schematic diagrams depict the circuits contained within each assembly of the 3400A as well as assembly interconnection. Main signal paths and significant feedback paths are identified.

6-5. The schematic diagrams are arranged in ascending order of assembly reference designation.

6-6. PARTS LOCATION DIAGRAMS

6-7. The parts location diagrams show the physical location of parts within an assembly. Parts are identified by reference designation. A parts location diagram is included for each assembly which does not have adequate silk screening of reference designations.

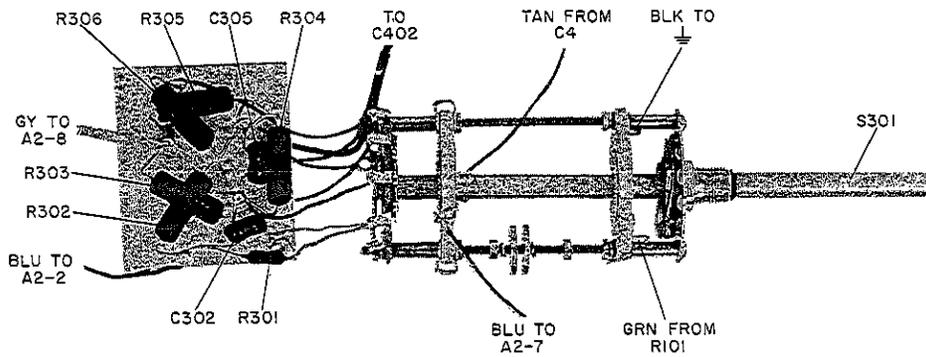
6-8. The parts location diagrams are located on the same figure as the schematic of the assembly.

GENERAL SCHEMATIC NOTES

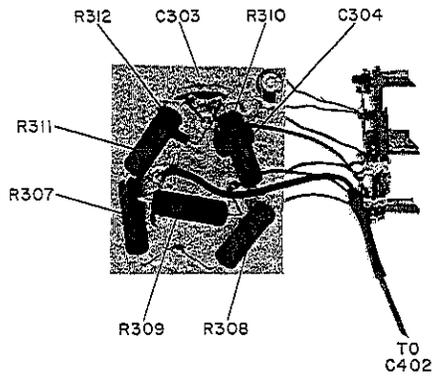
1. COMPLETE REFERENCE DESIGNATIONS ARE SHOWN.
2. COMPONENT VALUES ARE SHOWN AS FOLLOWS UNLESS OTHERWISE NOTED.
 RESISTANCE IN OHMS
 CAPACITANCE IN MICROFARADS
3.  DENOTES POWER LINE GROUND (VOLTMETER CHASSIS \perp).
 DENOTES CIRCUIT GROUND; ON PRINTED CIRCUIT ASSEMBLY.
4.  DENOTES ASSEMBLY.
 DENOTES MAIN SIGNAL PATH.
 DENOTES DC FEEDBACK PATH.
 DENOTES AC FEEDBACK PATH.
 DENOTES SHIELD.
5.  DENOTES FRONT PANEL MARKING.
 DENOTES REAR PANEL MARKING.
 DENOTES SCREWDRIVER ADJUST.
6.  DENOTES COMPONENTS NOT MOUNTED ON ASSEMBLY.
7. * AVERAGE VALUE SHOWN, OPTIMUM VALUE SELECTED AT FACTORY. SEE TABLE 5-7.
8.  DENOTES SECOND APPEARANCE OF A CONNECTOR PIN.

NOTES

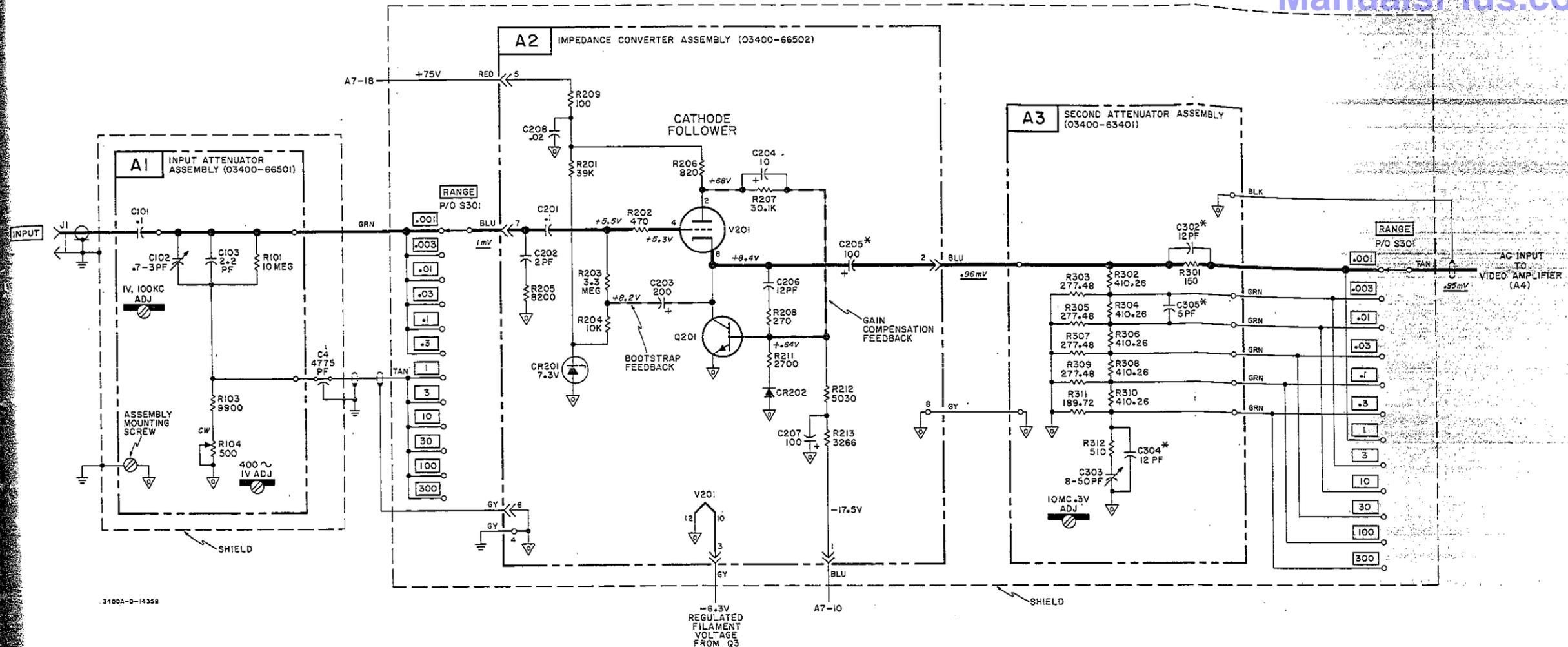
1. ALL DC AND AC VOLTAGE LEVELS SHOWN IN RED ARE WITH 1 MV INPUT (FULL SCALE DEFLECTION). A TOLERANCE OF $\pm 10\%$ SHOULD BE ALLOWED FOR VARIATIONS FROM INSTRUMENT TO INSTRUMENT.
2. ALL AC VOLTAGES ARE UNDERLINED>. ALL DC VOLTAGES HAVE A POLARITY INDICATION.



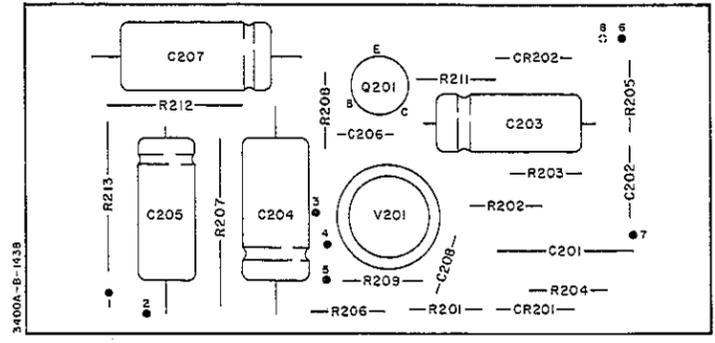
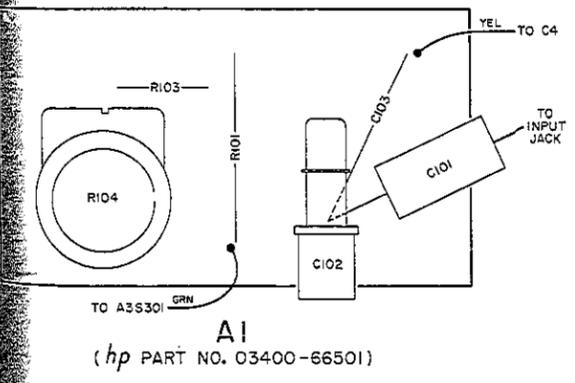
3400A-A-0107



A3
 (hp PART NO. 03400-63401)
 (BOARD ONLY)



3400A-D-1435B

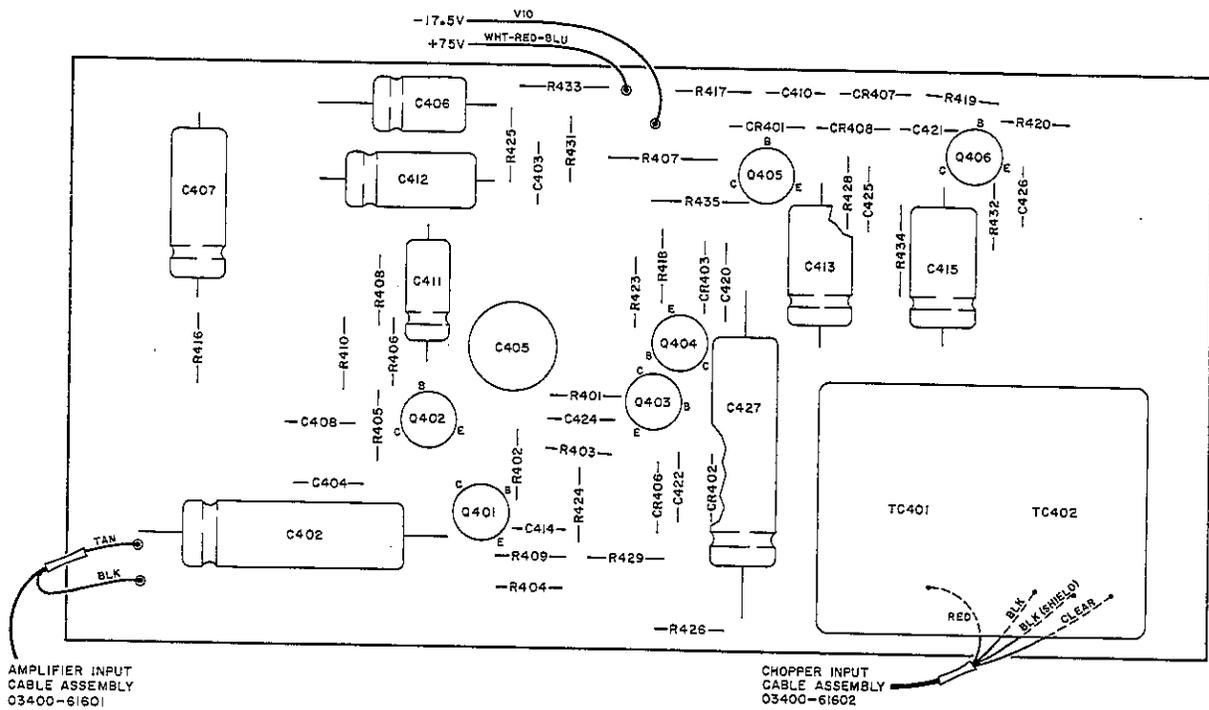


- 1 BLU A7-10
- 2 BLU A3R302
- 3 GY Q3 EMITTER
- 4 GY C2 (1/2)
- 5 RED A7-18
- 6 GY C4 (1/2)
- 7 BLU S301
- 8 GY A3R305 (1/2)

Figure 6-1. Input Attenuator A1, Impedance Converter A2, and Second Attenuator A3 Schematic and Parts Location Diagram
6-3/6-4

NOTES

1. ALL DC AND AC VOLTAGE LEVELS SHOWN IN RED ARE WITH 1 MV INPUT (FULL SCALE DEFLECTION). A TOLERANCE OF $\pm 10\%$ SHOULD BE ALLOWED FOR VARIATIONS FROM INSTRUMENT TO INSTRUMENT.
2. ALL AC VOLTAGES ARE UNDERLINED. ALL DC VOLTAGES HAVE A POLARITY INDICATION.
3. AC VOLTAGE LEVELS AT Q405 AND Q406 MUST BE OBSERVED WITH 10:1 DIVIDER PROBE.
4. IF C427 IS REPLACED, IT MAY BE NECESSARY TO SELECT THE VALUE OF C427 FOR PROPER FREQUENCY RESPONSE. THIS IS DUE TO CAPACITOR TOLERANCE.



A4

(hp PART NO. 03400-66503)

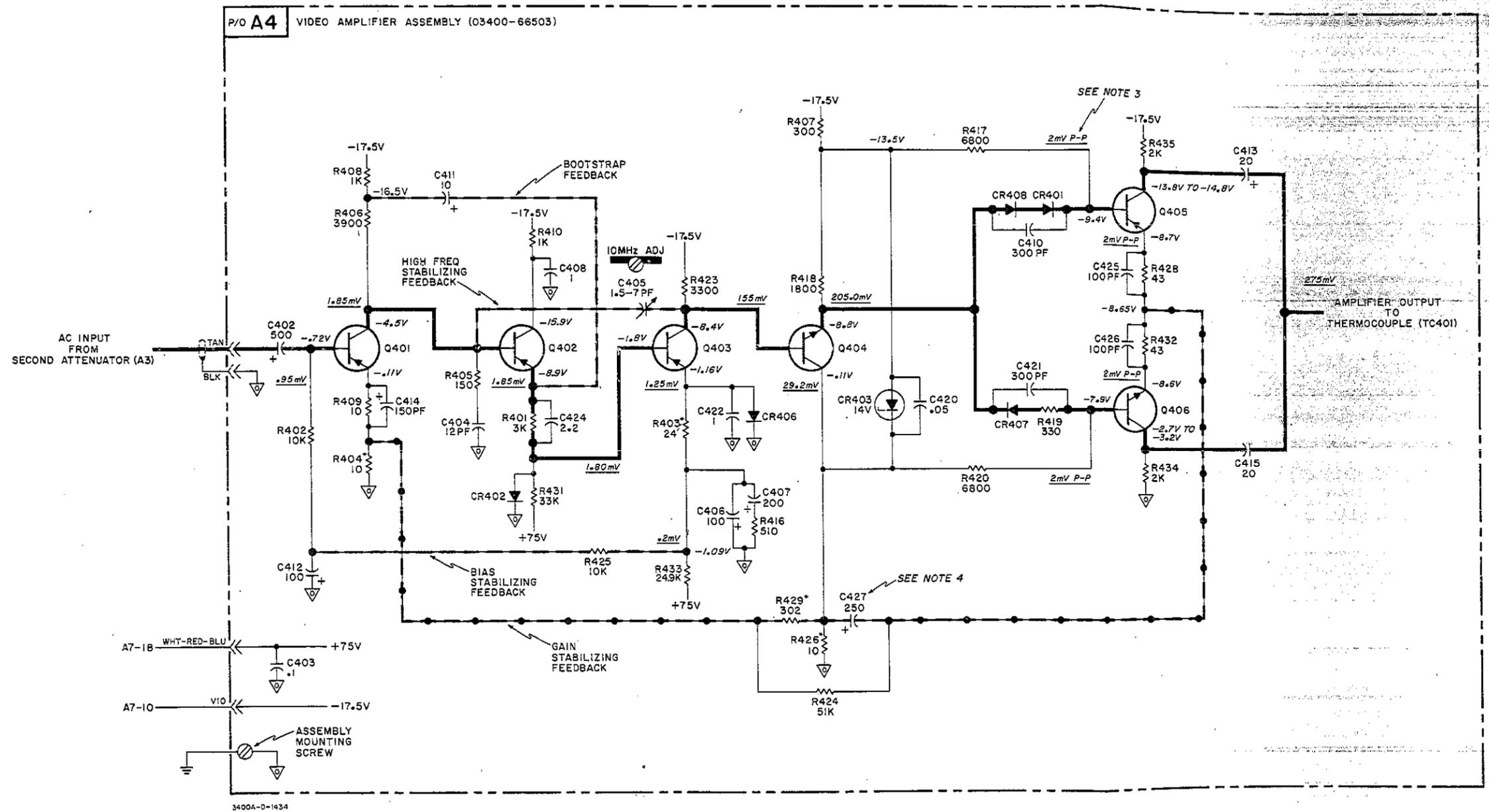
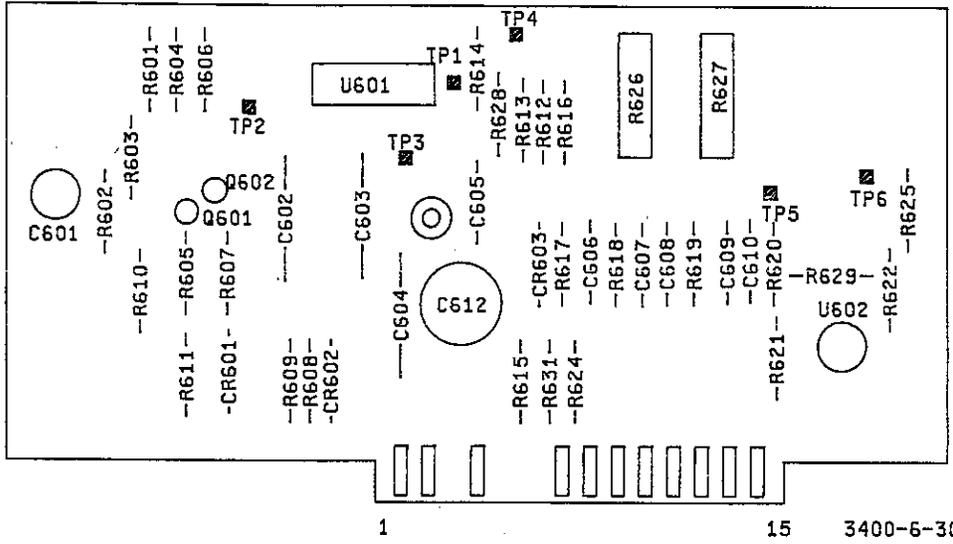
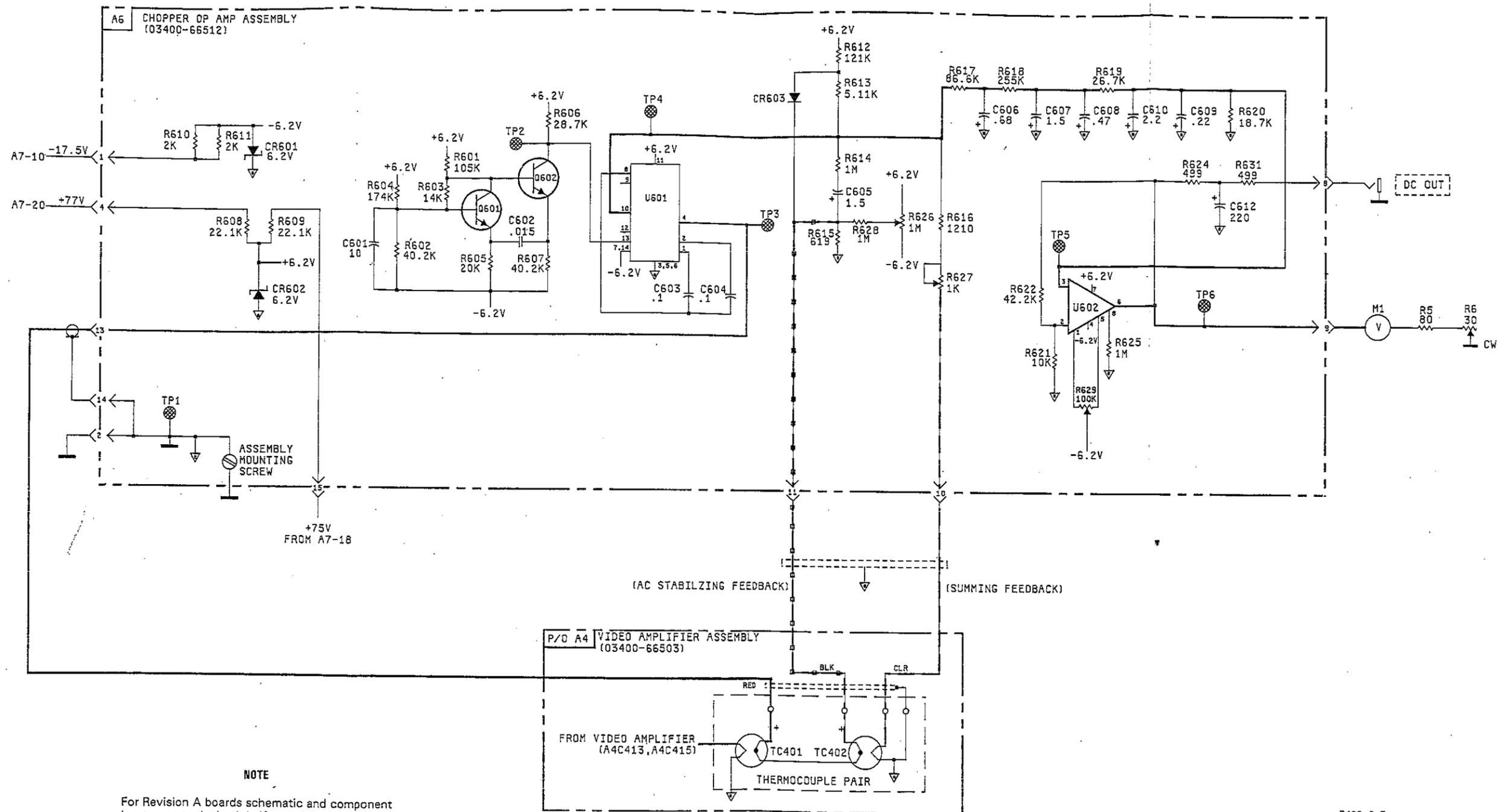


Figure 6-2. Video Amplifier A4 Schematic and Parts Location Diagram 6-5/6-6



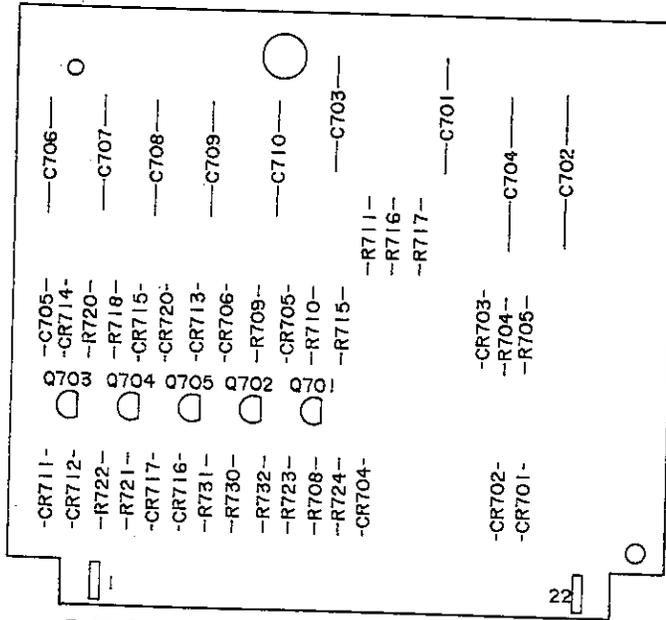
A6
(REV. C)
(-hp- Part Number 03400-66512)

3400-6-3C



3400-6-3

Figure 6-3. Chopper Amplifier A6 and Thermocouple Pair
(Part of A4) Schematic and Parts Location Diagram
6-7/6-8



3400-6-4C

A7
(REV. A)
(hp Part Number 03400-66510)

NOTE

Some 3400's have capacitors C3A and C3B connected across the ac line, as shown below. If any capacitor is defective, remove the defective capacitor but do NOT replace it with a good one.

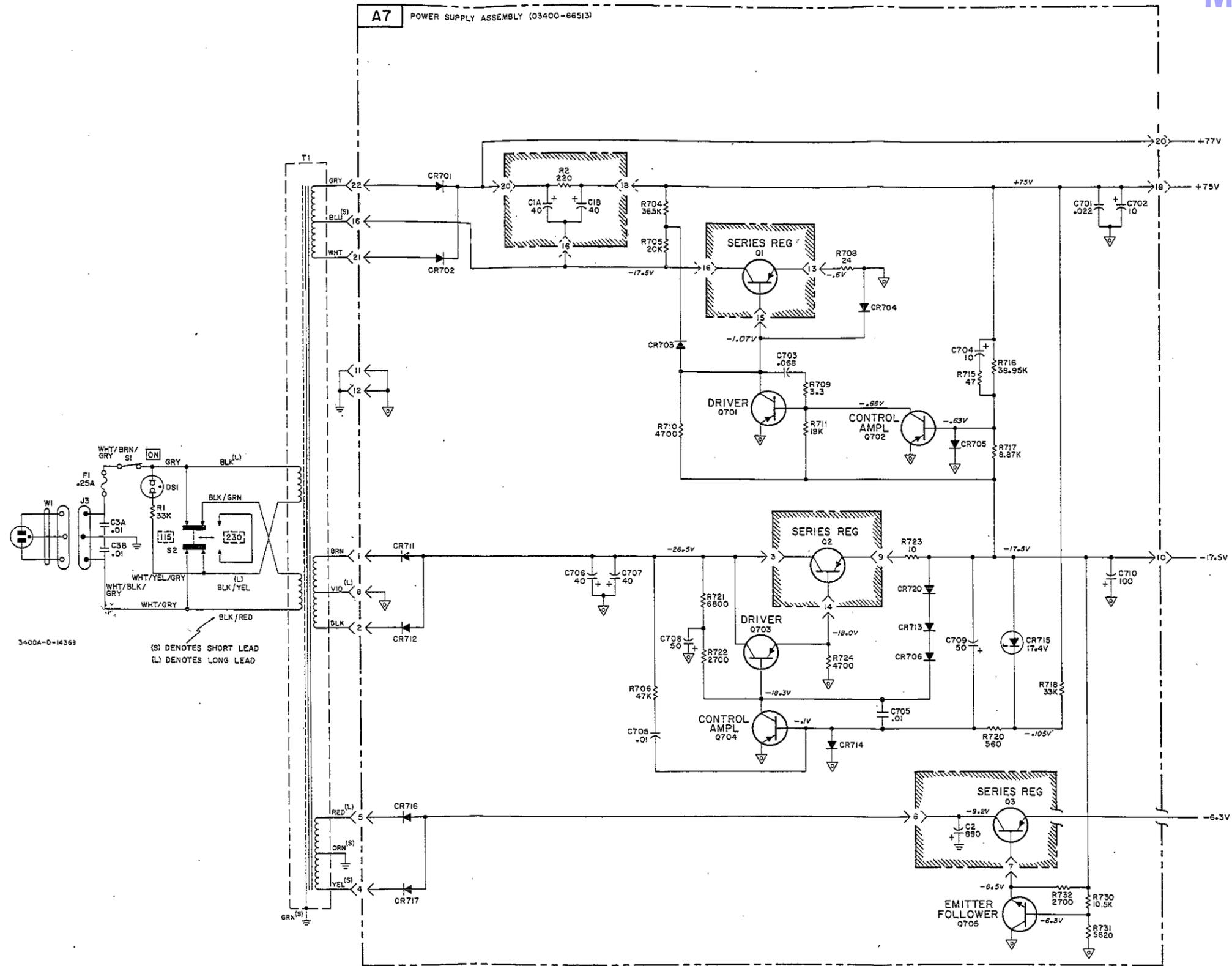


Figure 6-4. Power Supply A7 Schematic and Parts Location
6-9/6-10

SECTION VII

REPLACEABLE PARTS

7-1. INTRODUCTION

7-2. This section contains information for ordering replacement parts. Table 7-1 lists parts in alphameric order of their reference designators and indicates the description, -hp- part number for each part, together with any applicable notes, and provides the following:

- a. Total quantity used in the instrument (TQ column). The total quantity of a part is given the first time the part number appears.
- b. Description of the part. (See list of abbreviations below.)
- c. Typical manufacturer of the part in a five digit code.
- d. Manufacturer's part number.

7-3. Miscellaneous parts are listed at the end of Table 7-1.

7-4. ORDERING INFORMATION

7-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office. Identify parts by their Hewlett-Packard part numbers. Include instrument model and serial numbers.

7-6. NON-LISTED PARTS

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

- a. Instrument model number.
- b. Instrument serial number.
- c. Description of the part.
- d. Function and location of the part.

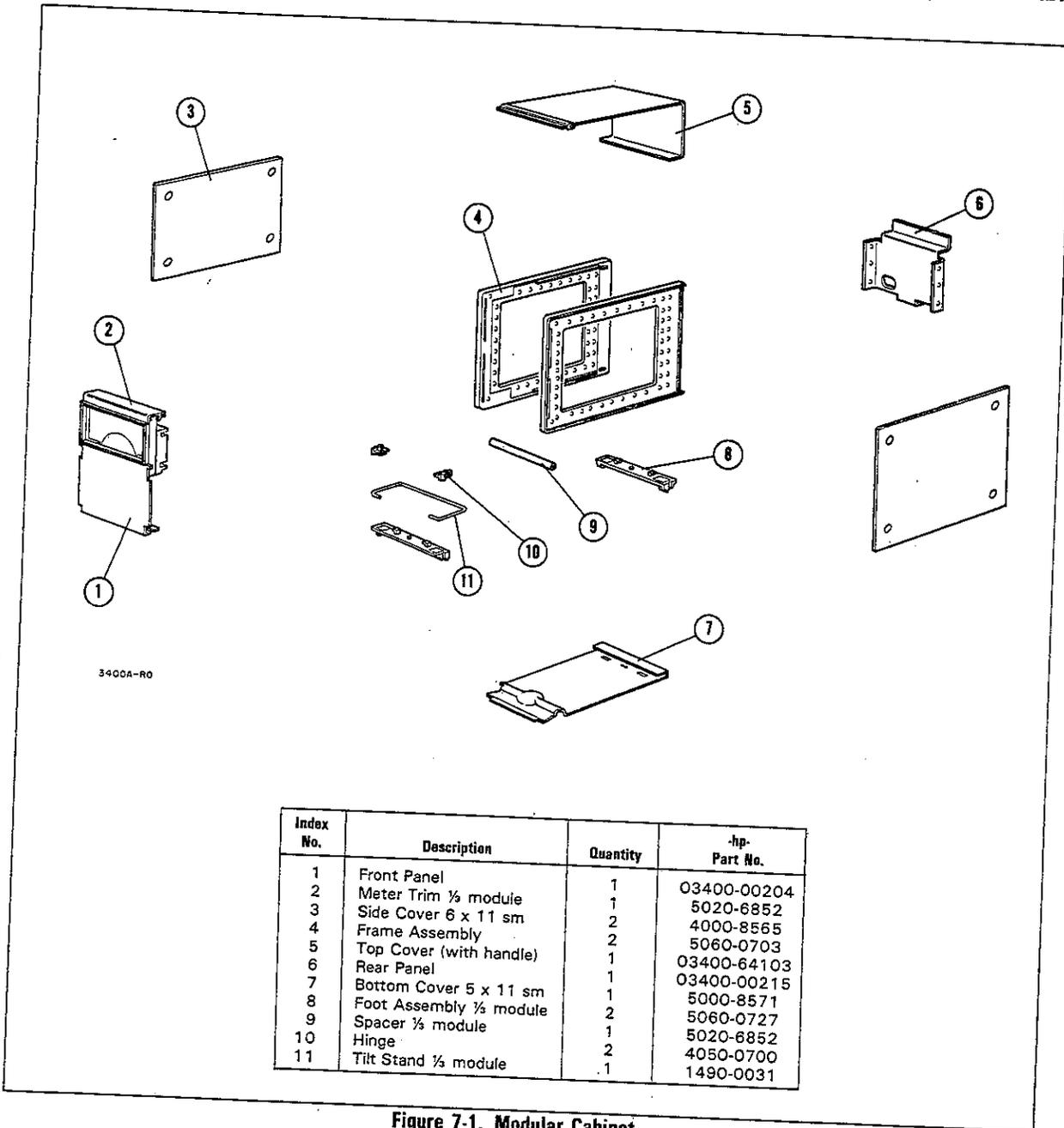


Figure 7-1. Modular Cabinet

Table 7-3. Replaceable Parts

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|--------------------|
| A1 | 03400-66501 | 0 | 1 | ASSEMBLY-INPUT ATTENUATOR BOARD | 28480 | 03400-66501 |
| A2 | 03400-66502 | 1 | 1 | ASSEMBLY-IMPEDANCE CONVERTER BOARD | 28480 | 03400-66502 |
| A3 | 03400-63401 | 3 | 1 | ASSEMBLY-SECOND ATTENUATOR | 28480 | 03400-63401 |
| A4 | 03400-66503 | 2 | 1 | ASSEMBLY-AMPLIFIER BOARD | 28480 | 03400-66503 |
| A6 | 03400-66512 | 3 | 1 | ASSEMBLY-CHOPPER OP AMP | 28480 | 03400-66512 |
| A7 | 03400-66513 | 4 | 1 | ASSEMBLY-POWER SUPPLY BOARD | 28480 | 03400-66513 |
| C1 | 0180-0152 | 5 | 1 | CAPACITOR-FXD 40UF+30-10% 200VDC AL | 28480 | 0180-0152 |
| C2 | 0180-0148 | 9 | 1 | CAPACITOR-FXD 890UF+100-10% 15VDC AL | 28480 | 0180-0148 |
| C4 | 0160-0379 | 6 | 1 | CAPACITOR-FDTHRU 4775PF 10% 500V MICA | 72982 | 633-010 1801 47750 |
| C101 | 0170-0022 | 7 | 1 | CAPACITOR-FXD .1UF +-20% 600VDC POLYE | 28480 | 0170-0022 |
| C102 | 0132-0003 | 4 | 1 | CAPACITOR-V TRMR-PSTN 7-3PF 350V | 28480 | 0132-0003 |
| C103 | 0150-0058 | 7 | 1 | CAPACITOR-FXD 2.2PF +-25PF 600VDC CER | 28480 | 0150-0058 |
| C201 | 0160-2671 | 5 | 1 | CAPACITOR-FXD .1UF +-5% 80VDC POLYE | 28480 | 0160-2671 |
| C202 | 0150-0031 | 6 | 1 | CAPACITOR-FXD 2PF +-5% 500VDC TI DIOX | 28480 | 0150-0031 |
| C203 | 0180-0060 | 4 | 2 | CAPACITOR-FXD 200UF+75-10% 3VDC AL | 56289 | 30D2075013CC2 |
| C204 | 0180-0059 | 7 | 3 | CAPACITOR-FXD 10UF+50-10% 150VDC AL | 56289 | 30D106F150DD2 |
| C205* | 0180-0039 | 7 | 2 | CAPACITOR-FXD 100UF+75-10% 12VDC AL | 56289 | 30D1076012CC2 |
| C206 | 0140-0201 | 1 | 2 | CAPACITOR-FXD 12PF +-5% 500VDC MICA | 72136 | DM15C120J0500WV1CR |
| C207 | 0180-0061 | 5 | 1 | CAPACITOR-FXD 100UF+75-10% 16VDC AL | 56289 | 30D1076016DC2 |
| C208 | 0150-0024 | 7 | 1 | CAPACITOR-FXD .02UF +80-20% 100VDC CER | 28480 | 0150-0024 |
| C302* | 0160-0987 | 1 | 1 | CAPACITOR-FXD 12PF+-10% 500VDC MICA | 28480 | 0160-0987 |
| C303 | 0121-0039 | 3 | 1 | CAPACITOR-V TRMR-CER 8-50PF 350V PNL-MTG | 72982 | 557-062 58-50 |
| C304* | 0160-0987 | 2 | 2 | CAPACITOR-FXD 12PF +-5% 500VDC MICA | 28480 | 0160-0987 |
| C305* | 0160-0987 | 2 | 2 | CAPACITOR-FXD 12PF +-5% 500VDC MICA | 28480 | 0160-0987 |
| C402 | 0180-0063 | 7 | 1 | CAPACITOR-FXD 500UF+75-10% 3VDC AL | 56289 | 30D507003DF2 |
| C403 | 0160-0269 | 3 | 1 | CAPACITOR-FXD .1UF +-20% 500VDC CER | 28480 | 0160-0269 |
| C404 | 0140-0201 | 1 | 1 | CAPACITOR-FXD 12PF +-5% 500VDC MICA | 72136 | DM15C120J0500WV1CR |
| C405 | 0130-0018 | 7 | 1 | CAPACITOR-V TRMR-CER 1.5-7PF 350V PC-MTG | 28480 | 0130-0018 |
| C406 | 0180-0137 | 6 | 1 | CAPACITOR-FXD 100UF+-20% 10VDC TA | 56289 | 150D107X0010R2 |
| C407 | 0180-0060 | 4 | 1 | CAPACITOR-FXD 200UF+75-10% 3VDC AL | 56289 | 30D2076003CC2 |
| C408 | 0160-0127 | 2 | 2 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| C410 | 0140-0225 | 9 | 2 | CAPACITOR-FXD 300PF +-1% 300VDC MICA | 72136 | DM15F301F0300WV1C |
| C411 | 0180-0224 | 2 | 1 | CAPACITOR-FXD 10UF+75-10% 16VDC AL | 56289 | 30D1060165A2 |
| C412 | 0180-0039 | 7 | 2 | CAPACITOR-FXD 100UF+75-10% 12VDC AL | 56289 | 30D1076012CC2 |
| C413 | 0180-0142 | 3 | 2 | CAPACITOR-FXD 20UF+100-10% 25VDC AL SPOL | 28480 | 0180-0142 |
| C414 | 0140-0196 | 3 | 1 | CAPACITOR-FXD 150PF +-5% 300VDC MICA | 72136 | DM15F151J0300WV1CR |
| C415 | 0180-0142 | 3 | 3 | CAPACITOR-FXD 20UF+100-10% 25VDC AL SPOL | 28480 | 0180-0142 |
| C420 | 0150-0096 | 3 | 1 | CAPACITOR-FXD .05UF +80-20% 100VDC CER | 28480 | 0150-0096 |
| C421 | 0140-0225 | 9 | 1 | CAPACITOR-FXD 300PF +-1% 300VDC MICA | 72136 | DM15F301F0300WV1C |
| C422 | 0160-0127 | 2 | 3 | CAPACITOR-FXD 1UF +-20% 25VDC CER | 28480 | 0160-0127 |
| C424 | 0160-0128 | 3 | 1 | CAPACITOR-FXD 2.2UF +-20% 50VDC CER | 28480 | 0160-0128 |
| C425 | 0140-0176 | 9 | 2 | CAPACITOR-FXD 100PF +-2% 300VDC MICA | 72136 | DM15F101G0300WV1CR |
| C426 | 0140-0176 | 9 | 2 | CAPACITOR-FXD 100PF +-2% 300VDC MICA | 72136 | DM15F101G0300WV1CR |
| C427* | 0180-2428 | 2 | 1 | CAPACITOR-FXD 250UF+75-10% 25VDC AL | 56289 | 50D2576025EF7 |
| C601 | 0180-2822 | 0 | 1 | CAPACITOR-FXD 10UF+50-10% 50VDC TA | 28480 | 0180-2822 |
| C602 | 0160-0194 | 3 | 1 | CAPACITOR-FXD .015UF +-10% 200VDC POLYE | 28480 | 0160-0194 |
| C603 | 0160-0168 | 1 | 2 | CAPACITOR-FXD .1UF +-10% 200VDC POLYE | 28480 | 0160-0168 |
| C604 | 0160-0168 | 1 | 1 | CAPACITOR-FXD .1UF +-10% 200VDC POLYE | 28480 | 0160-0168 |
| C605 | 0180-1745 | 4 | 2 | CAPACITOR-FXD 1.5UF+-10% 20VDC TA | 56289 | 150D155X9020A2 |
| C606 | 0180-0373 | 2 | 1 | CAPACITOR-FXD .68UF+-10% 35VDC TA | 56289 | 150D684X9035A2 |
| C607 | 0180-1745 | 4 | 1 | CAPACITOR-FXD 1.5UF+-10% 20VDC TA | 56289 | 150D155X9020A2 |
| C608 | 0180-0376 | 5 | 1 | CAPACITOR-FXD .47UF+-10% 35VDC TA | 56289 | 150D474X9035A2 |
| C609 | 0180-1735 | 2 | 1 | CAPACITOR-FXD .22UF+-10% 35VDC TA | 56289 | 150D224X9035A2 |
| C610 | 0180-0197 | 8 | 1 | CAPACITOR-FXD 2.2UF+-10% 20VDC TA | 56289 | 150D225X9020A2 |
| C612 | 0180-0692 | 8 | 1 | CAPACITOR-FXD 220UF+50-10% 35VDC AL | 01494 | 35V8SL20 |
| C701 | 0170-0024 | 9 | 1 | CAPACITOR-FXD .022UF +-20% 200VDC POLYE | 28480 | 0170-0024 |
| C702 | 0180-0089 | 9 | 1 | CAPACITOR-FXD 10UF+50-10% 150VDC AL | 56289 | 30D106F150DD2 |
| C703 | 0160-0166 | 7 | 1 | CAPACITOR-FXD .068UF +-10% 200VDC POLYE | 28480 | 0160-0166 |
| C704 | 0180-0089 | 7 | 1 | CAPACITOR-FXD 10UF+50-10% 150VDC AL | 56289 | 30D106F150DD2 |
| C705 | 0150-0012 | 3 | 1 | CAPACITOR-FXD .01UF +-20% 1KVDC CER | 56289 | C023A1 02J103MS38 |
| C706 | 0180-0050 | 2 | 2 | CAPACITOR-FXD 40UF+75-10% 50VDC AL | 56289 | 30D406050DD2 |
| C707 | 0180-0050 | 2 | 2 | CAPACITOR-FXD 40UF+75-10% 50VDC AL | 56289 | 30D406050DD2 |
| C708 | 0180-0105 | 8 | 2 | CAPACITOR-FXD 50UF+100-10% 25VDC AL SPOL | 28480 | 0180-0105 |
| C709 | 0180-0105 | 8 | 1 | CAPACITOR-FXD 50UF+100-10% 25VDC AL SPOL | 28480 | 0180-0105 |
| C710 | 0180-0098 | 8 | 1 | CAPACITOR-FXD 100UF+-20% 20VDC TA | 56289 | 150D107X0020S2 |
| CR201 | 1902-0045 | 8 | 1 | DIODE-ZNR 7.32V 2% DO-35 PD=.4W | 28480 | 1912-0045 |
| CR202 | 1901-0025 | 1 | 8 | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR401 | 1901-0025 | 1 | 2 | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0025 |
| CR402 | 1901-0040 | 2 | 2 | DIODE-SWITCHING 30V 50MA 2NS DO-35 | 28480 | 1901-0040 |
| CR403 | 1902-0040 | 3 | 1 | DIODE-ZNR 14V 5% | 28480 | 1902-0040 |

See introduction to this section for ordering information
*Indicates factory selected value

Table 7-3. Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|---|----------|------------------|
| CR406 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | | |
| CR407 | 1910-0016 | 0 | 2 | DIODE-GE 60V 60MA 1US DO-7 | 28480 | 1901-0025 |
| CR408 | 1910-0016 | 0 | | DIODE-GE 60V 60MA 1US DO-7 | 28480 | 1910-0016 |
| CR601 | 1902-0777 | 3 | 2 | DIODE-ZNR 1N825 6.2V 5Z DO-7 PD=.4W | 28480 | 1910-0016 |
| CR602 | 1902-0777 | 3 | | DIODE-ZNR 1N825 6.2V 5Z DO-7 PD=.4W | 04713 | 1N825 |
| | | | | | 04713 | 1N825 |
| CR603 | 1901-0518 | 8 | 1 | DIODE-SM SIG SCHOTTKY | | |
| CR701 | 1901-0028 | 5 | 2 | DIODE-PWR RECT 400V 750MA DO-29 | 28480 | 1901-0518 |
| CR702 | 1901-0028 | 5 | | DIODE-PWR RECT 400V 750MA DO-29 | 28480 | 1901-0028 |
| CR703 | 1901-0025 | 5 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0028 |
| CR704 | 1901-0701 | 1 | 2 | DIODE-STABISTOR 12V 10MA | 28480 | 1901-0025 |
| | | | | | 28480 | 1901-0701 |
| CR705 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | | |
| CR706 | 1901-0701 | 1 | | DIODE-STABISTOR 12V 10MA | 28480 | 1901-0025 |
| CR711 | 1901-0026 | 3 | 2 | DIODE-PWR RECT 200V 750MA DO-29 | 28480 | 1901-0701 |
| CR712 | 1901-0026 | 3 | | DIODE-PWR RECT 200V 750MA DO-29 | 28480 | 1901-0026 |
| CR713 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | 28480 | 1901-0026 |
| | | | | | 28480 | 1901-0025 |
| CR714 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | | |
| CR715 | 1902-3223 | 0 | 1 | DIODE-ZNR 17.4V 2Z DO-35 PD=.4W | 28480 | 1901-0025 |
| CR716 | 1901-0045 | 6 | 2 | DIODE-PWR RECT 100V 750MA DO-29 | 28480 | 1902-3223 |
| CR717 | 1901-0045 | 6 | | DIODE-PWR RECT 100V 750MA DO-29 | 28480 | 1901-0045 |
| | | | | | 28480 | 1901-0045 |
| CR720 | 1901-0025 | 2 | | DIODE-GEN PRP 100V 200MA DO-7 | | |
| DS1 | 1450-0566 | 9 | 1 | LIGHT-IND WHT-TL .4-DIA SLDR-LUC-TERM | 28480 | 1901-0025 |
| F1 | 2110-0004 | 1 | 1 | FUSE .25A 250V NTD 1.25X.25 UL | 91802 | 2910S21 |
| J1 | 1250-0118 | 3 | 1 | CONNECTOR-RF BNC FEM SCL-HOLE-FR 50-OHM | 28480 | 2110-0004 |
| J2 | 1251-0205 | 1 | 1 | CONNECTOR-TEL JACK 2-CKT .25-SHK-DIA | 28480 | 1250-0118 |
| J3 | 1251-2357 | 8 | 1 | CONNECTOR-AC PWR HP-9 MALE FLG-MTG | 28480 | 1251-0205 |
| J4 | 1251-0208 | 4 | 1 | CONNECTOR-PC EDGE 22-CONT/ROW 1-ROW | 28480 | 1251-2357 |
| J5 | 1251-0194 | 7 | 1 | CONNECTOR-PC EDGE 15-CONT/ROW 1-ROW | 28480 | 1251-0208 |
| | | | | | 28480 | 1251-0194 |
| M1 | 1120-0320 | 4 | 1 | METER-3MA | 28480 | 1120-0320 |
| M1 | 1120-0308 | 8 | 1 | METER-DB SCALE (OPT. 001 ONLY) | 28480 | 1120-0308 |
| Q1 | 1853-0063 | 5 | 1 | TRANSISTOR PNP SI TO-3 PD=150W FT=3MHZ | | |
| Q2 | 1853-0305 | 8 | 1 | TRANSISTOR PNP 2N5875 SI TO-3 PD=150W | 28480 | 1853-0063 |
| Q3 | 1853-0511 | 6 | 1 | TRANSISTOR PNP 2N3792 SI TO-3 PD=150W | 04713 | 2N5875 |
| Q201 | 1853-0213 | 1 | 2 | TRANSISTOR NPN SI PD=350MW FT=300MHZ | 04713 | 2N3792 |
| Q401 | 1853-0288 | 6 | 4 | TRANSISTOR PNP SI TO-18 PD=360MW | 04713 | 2N3904 |
| | | | | | 28480 | 1853-0288 |
| Q402 | 1853-0288 | 6 | | TRANSISTOR PNP SI TO-18 PD=360MW | 28480 | 1853-0288 |
| Q403 | 1853-0288 | 6 | | TRANSISTOR PNP SI TO-18 PD=360MW | 28480 | 1853-0288 |
| Q404 | 1854-0354 | 9 | 2 | TRANSISTOR NPN SI TO-52 PD=360MW | 28480 | 1854-0354 |
| Q405 | 1853-0288 | 6 | | TRANSISTOR PNP SI TO-18 PD=360MW | 28480 | 1853-0288 |
| Q406 | 1854-0354 | 9 | | TRANSISTOR NPN SI TO-52 PD=360MW | 28480 | 1854-0354 |
| Q601 | 1854-0226 | 4 | 2 | TRANSISTOR NPN 2N4384 SI TO-18 PD=500MW | 13606 | 2N4384 |
| Q602 | 1854-0226 | 4 | | TRANSISTOR NPN 2N4384 SI TO-18 PD=500MW | 13606 | 2N4384 |
| Q701 | 1853-0066 | 8 | 2 | TRANSISTOR PNP SI TO-92 PD=625MW | 28480 | 1853-0066 |
| Q702 | 1853-0066 | 8 | | TRANSISTOR PNP SI TO-92 PD=625MW | 28480 | 1853-0066 |
| Q703 | 1853-0066 | 2 | 2 | TRANSISTOR PNP SI PD=310MW FT=40MHZ | 27014 | 2N5087 |
| Q704 | 1853-0066 | 2 | | TRANSISTOR PNP SI PD=310MW FT=40MHZ | 27014 | 2N5087 |
| Q705 | 1854-0213 | 1 | 1 | TRANSISTOR NPN SI PD=350MW FT=300MHZ | 04713 | 2N3904 |
| R1 | 0687-3331 | 2 | 1 | RESISTOR 33K 10% .5W CC TC=0+765 | 01121 | EB3331 |
| R2 | 0687-2211 | 5 | 1 | RESISTOR 220 10% .5W CC TC=0+529 | 01121 | EB2211 |
| R5 | 0812-0048 | 9 | 1 | RESISTOR 80 3% .75W PW TC=0+20 | 91637 | RS1/2-T9-80R-H |
| R6 | 2100-0721 | 8 | 1 | RESISTOR-TRMR 30 20% WW SIDE-ADJ 1-TRN | 28480 | 2100-0721 |
| R101 | 0698-4128 | 8 | 1 | RESISTOR 10M .25% 1W F TC=0+50 | 28480 | 0698-4128 |
| R103 | 0698-6204 | 7 | 1 | RESISTOR 9.9K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-9901-F |
| R104 | 2100-0554 | 5 | 1 | RESISTOR-TRMR 500 10% C TOP-ADJ 1-TRN | 28480 | 2100-0554 |
| R201 | 0683-3935 | 4 | 1 | RESISTOR 39K 5% .25W FC TC=-400/+800 | 01121 | C3935 |
| R202 | 0683-4715 | 0 | 1 | RESISTOR 470 5% .25W FC TC=-400/+600 | 01121 | C34715 |
| R203 | 0683-3355 | 2 | 1 | RESISTOR 3.3M 5% .25W FC TC=-900/+1100 | 01121 | C3355 |
| R204 | 0683-1035 | 1 | 3 | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | C81035 |
| R205 | 0683-8225 | 5 | 1 | RESISTOR 8.2K 5% .25W FC TC=-400/+700 | 01121 | C88225 |
| R206 | 0683-8215 | 3 | 1 | RESISTOR 820 5% .25W FC TC=-400/+600 | 01121 | C88215 |
| R207 | 0757-0348 | 9 | 1 | RESISTOR 30.1K .5% .25W FC TC=-400/+600 | 28480 | 0757-0348 |
| R208 | 0683-2715 | 6 | 1 | RESISTOR 270 5% .25W FC TC=-400/+600 | 01121 | C82715 |
| R209 | 0683-1015 | 7 | 1 | RESISTOR 100 5% .25W FC TC=-400/+500 | 01121 | C81015 |
| R211 | 0683-2725 | 8 | 3 | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | C82725 |
| R212 | 0727-0136 | 5 | 1 | RESISTOR 5.03K 1% .5W CF TC=0-500 | 28480 | 0727-0136 |
| R213 | 0737-0126 | 3 | 1 | RESISTOR 3.266K 1% .5W CF TC=0-500 | 91637 | DCS1/2-3266R-F |
| R301 | 0737-0715 | 9 | 1 | RESISTOR 150 1% .25W F TC=0+100 | 24546 | C5-1/4-T0-151-F |
| R302 | 0698-4119 | 8 | 5 | RESISTOR 410.26 .1% .25W F TC=0+100 | 28480 | 0698-4119 |
| R303 | 0698-4118 | 9 | 4 | RESISTOR 277.48 .1% .25W F TC=0+100 | 28480 | 0698-4118 |
| R304 | 0698-4119 | 9 | | RESISTOR 410.26 .1% .25W F TC=0+100 | 28480 | 0698-4119 |
| R305 | 0698-4118 | 8 | | RESISTOR 277.48 .1% .25W F TC=0+100 | 28480 | 0698-4118 |
| R306 | 0698-4119 | 9 | | RESISTOR 410.26 .1% .25W F TC=0+100 | 28480 | 0698-4119 |

See introduction to this section for ordering information
*Indicates factory selected value

Table 7-3. Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|--|----------|------------------|
| R307 | 0698-4118 | 8 | | RESISTOR 277.48 .1% .25W F TC=0+100 | 28480 | 0698-4118 |
| R308 | 0698-4119 | 9 | | RESISTOR 410.25 .1% .25W F TC=0+100 | 28480 | 0698-4119 |
| R309 | 0698-4118 | 8 | | RESISTOR 277.48 .1% .25W F TC=0+100 | 28480 | 0698-4118 |
| R310 | 0698-4119 | 9 | | RESISTOR 410.25 .1% .25W F TC=0+100 | 28480 | 0698-4119 |
| R311 | 0698-4117 | 7 | 1 | RESISTOR 189.72 .1% .25W F TC=0+100 | 28480 | 0698-4117 |
| R312 | 0683-5115 | 6 | | RESISTOR 510 5% .25W FC TC=-400/+600 | 01121 | CB5115 |
| R401 | 0683-3025 | 3 | 1 | RESISTOR 3K 5% .25W FC TC=-400/+700 | 01121 | CB3025 |
| R402 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| R403* | 0683-2405 | 1 | 2 | RESISTOR 24 5% .25W FC TC=-400/+500 | 01121 | CB2405 |
| R404* | 0757-0346 | 2 | 2 | RESISTOR 10 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-10R0-F |
| R405 | 0683-1515 | 2 | 1 | RESISTOR 150 5% .25W FC TC=-400/+600 | 01121 | CB1515 |
| R406 | 0683-3925 | 2 | 1 | RESISTOR 3.9K 5% .25W FC TC=-400/+700 | 01121 | CB3925 |
| R407 | 0727-0065 | 9 | 1 | RESISTOR 300 1% .5W CF TC=0-500 | 28480 | 0727-0065 |
| R408 | 0683-1025 | 9 | 2 | RESISTOR 1K 5% .25W FC TC=-400/+600 | 01121 | CB1025 |
| R409 | 0683-1005 | 5 | 1 | RESISTOR 10 5% .25W FC TC=-400/+500 | 01121 | CB1005 |
| R410 | 0683-1025 | 9 | | RESISTOR 1K 5% .25W FC TC=-400/+600 | 01121 | CB1025 |
| R416 | 0683-5115 | 6 | | RESISTOR 510 5% .25W FC TC=-400/+600 | 01121 | CB5115 |
| R417 | 0683-6825 | 7 | 3 | RESISTOR 6.8K 5% .25W FC TC=-400/+700 | 01121 | CB6825 |
| R418 | 0683-1825 | 7 | 1 | RESISTOR 1.8K 5% .25W FC TC=-400/+700 | 01121 | CB1825 |
| R419 | 0683-3315 | 4 | 1 | RESISTOR 330 5% .25W FC TC=-400/+600 | 01121 | CB3315 |
| R420 | 0683-6825 | 7 | | RESISTOR 6.8K 5% .25W FC TC=-400/+700 | 01121 | CB6825 |
| R423 | 0683-3325 | 6 | 1 | RESISTOR 3.3K 5% .25W FC TC=-400/+700 | 01121 | CB3325 |
| R424 | 0683-5135 | 0 | 1 | RESISTOR 51K 5% .25W FC TC=-400/+800 | 01121 | CB5135 |
| R425 | 0683-1035 | 1 | | RESISTOR 10K 5% .25W FC TC=-400/+700 | 01121 | CB1035 |
| R426* | 0757-0346 | 2 | | RESISTOR 10 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-10R0-F |
| R428 | 0683-4305 | 4 | 2 | RESISTOR 43 5% .25W FC TC=-400/+500 | 01121 | CB4305 |
| R429* | 0757-0346 | 1 | 1 | RESISTOR 302 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-302R-F |
| R431 | 0683-3335 | 8 | 2 | RESISTOR 33K 5% .25W FC TC=-400/+800 | 01121 | CB3335 |
| R432 | 0683-4305 | 4 | 2 | RESISTOR 43 5% .25W FC TC=-400/+500 | 01121 | CB4305 |
| R433 | 0698-3217 | 6 | 1 | RESISTOR 24.9K 1% .25W F TC=0+100 | 24546 | CS-1/4-T0-2492-F |
| R434 | 0757-0739 | 7 | 2 | RESISTOR 2K 1% .25W F TC=0+100 | 24546 | CS-1/4-T0-2001-F |
| R435 | 0757-0739 | 7 | | RESISTOR 2K 1% .25W F TC=0+100 | 24546 | CS-1/4-T0-2001-F |
| R601 | 0698-4524 | 0 | 1 | RESISTOR 174K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-1743-F |
| R602 | 0698-3499 | 6 | 2 | RESISTOR 40.2K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-4022-F |
| R603 | 0698-4479 | 4 | 1 | RESISTOR 14K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-1402-F |
| R604 | 0698-4514 | 8 | 1 | RESISTOR 105K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-1053-F |
| R605 | 0757-0449 | 6 | 1 | RESISTOR 20K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-2002-F |
| R606 | 0698-3449 | 6 | 1 | RESISTOR 28.7K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-2872-F |
| R607 | 0698-3499 | 6 | | RESISTOR 40.2K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-4022-F |
| R608 | 0757-0450 | 9 | 2 | RESISTOR 22.1K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-2212-F |
| R609 | 0757-0450 | 9 | | RESISTOR 22.1K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-2212-F |
| R610 | 0683-2025 | 1 | 2 | RESISTOR 2K 5% .25W FC TC=-400/+700 | 01121 | CB2025 |
| R611 | 0683-2025 | 1 | | RESISTOR 2K 5% .25W FC TC=-400/+700 | 01121 | CB2025 |
| R612 | 0757-0467 | 8 | 1 | RESISTOR 121K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-1213-F |
| R613 | 0757-0438 | 3 | 1 | RESISTOR 5.11K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-5111-F |
| R614 | 0698-7332 | 4 | 2 | RESISTOR 1M 1% .125W F TC=0+100 | 28480 | 0698-7332 |
| R615 | 0757-0276 | 7 | 1 | RESISTOR 61.9 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-6192-F |
| R616 | 0757-0274 | 7 | 1 | RESISTOR 1.21K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-1211-F |
| R617 | 0698-4511 | 5 | 1 | RESISTOR 86.6K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-8662-F |
| R618 | 0698-3149 | 3 | 1 | RESISTOR 255K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-2553-F |
| R619 | 0698-4488 | 5 | 1 | RESISTOR 26.7K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-2672-F |
| R620 | 0698-4483 | 0 | 1 | RESISTOR 18.7K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-1872-F |
| R621 | 0757-0442 | 9 | 1 | RESISTOR 10K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-1002-F |
| R622 | 0698-3450 | 9 | 1 | RESISTOR 42.2K 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-4222-F |
| R624 | 0698-4123 | 5 | 2 | RESISTOR 499 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-499R-F |
| R625 | 0698-7332 | 4 | 1 | RESISTOR 1M 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-1004-F |
| R626 | 2100-3163 | 8 | 1 | RESISTOR-TRMR 1M 20% C SIDE-ADJ 17-TRN | 02111 | 43P105 |
| R627 | 2100-3154 | 7 | 1 | RESISTOR-TRMR 1K 10% C SIDE-ADJ 17-TRN | 02111 | 43P102 |
| R628 | 0698-7332 | 4 | | RESISTOR 1M 1% .125W F TC=0+100 | 28480 | 0698-7332 |
| R629 | 2100-3355 | 0 | 1 | RESISTOR-TRMR 100K 10% | 28480 | 2100-3355 |
| R631 | 0698-4123 | 5 | | RESISTOR 499 1% .125W F TC=0+100 | 24546 | C4-1/8-T0-499R-F |
| R704 | 0757-0768 | 9 | 1 | RESISTOR 36.5K 1% .25W F TC=0+100 | 24546 | CS-1/4-T0-3652-F |
| R705 | 0683-2635 | 3 | 1 | RESISTOR 20K 5% .25W FC TC=-400/+800 | 01121 | CB2035 |
| R708 | 0683-2405 | 1 | | RESISTOR 24 5% .25W FC TC=-400/+500 | 01121 | CB2405 |
| R709 | 0683-0335 | 2 | 1 | RESISTOR 3.3 5% .25W FC TC=-400/+500 | 01121 | CB3305 |
| R710 | 0683-4725 | 2 | 2 | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |
| R711 | 0687-1831 | 3 | 1 | RESISTOR 18K 10% .5W CC TC=0+765 | 01121 | EB1831 |
| R715 | 0683-4705 | 8 | 1 | RESISTOR 47 5% .25W FC TC=-400/+500 | 01121 | CB4705 |
| R716 | 0727-0188 | 7 | 1 | RESISTOR 38.95K .5% .5W CF TC=0-500 | 91637 | DCS-1/2-38951-D |
| R717 | 0998-4133 | 6 | 1 | RESISTOR 8.87K 1% .5W CF TC=0-50 | 28480 | 0998-4133 |
| R718 | 0683-3333 | 8 | | RESISTOR 33K 5% .25W FC TC=-400/+800 | 01121 | CB3333 |
| R720 | 0683-5615 | 1 | 1 | RESISTOR 560 5% .25W FC TC=-400/+600 | 01121 | CB5615 |
| R721 | 0683-6825 | 7 | | RESISTOR 6.8K 5% .25W FC TC=-400/+700 | 01121 | CB6825 |
| R722 | 0683-2725 | 8 | | RESISTOR 2.7K 5% .25W FC TC=-400/+700 | 01121 | CB2725 |
| R723 | 0684-1001 | 3 | 1 | RESISTOR 10 10% .25W FC TC=-400/+500 | 01121 | CB1001 |
| R724 | 0683-4725 | 2 | | RESISTOR 4.7K 5% .25W FC TC=-400/+700 | 01121 | CB4725 |

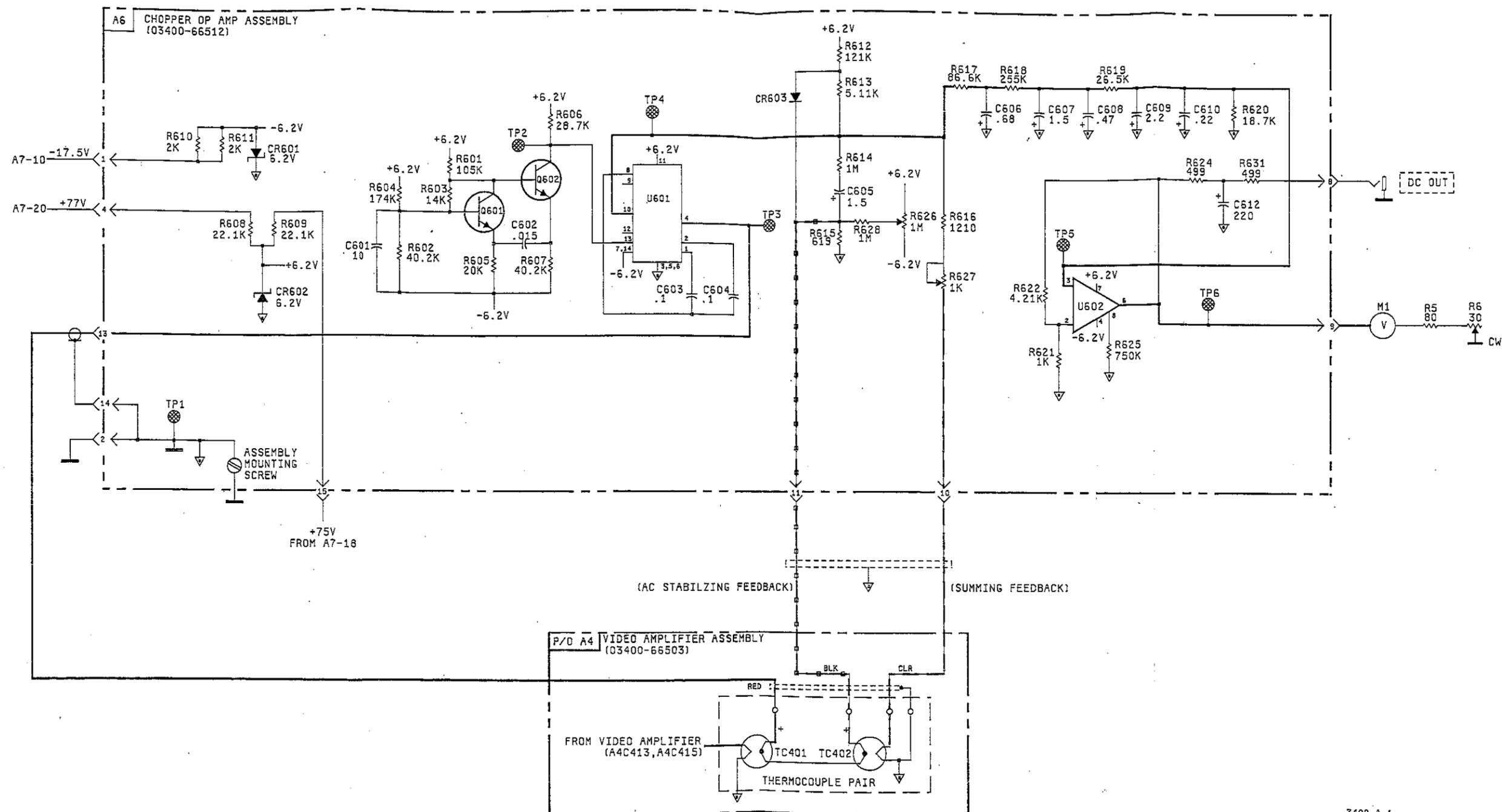
See introduction to this section for ordering information
*Indicates factory selected value

Table 7-3. Replaceable Parts (Cont'd)

| Reference Designation | HP Part Number | C D | Qty | Description | Mfr Code | Mfr Part Number |
|-----------------------|----------------|-----|-----|---|----------|--|
| R730 | 0698-4477 | 2 | 1 | RESISTOR 10.5K 1% .125W F TC=0+-100 | 24546 | |
| R731 | 0737-0200 | 7 | 1 | RESISTOR 5.62K 1% .125W F TC=0+-100 | 24546 | |
| R732 | 0603-2725 | 8 | 1 | RESISTOR 2.7K 5% .25W FC TC=400/+700 | 01121 | C4-1/8-T0-1052-F C4-1/8-T0-5621-F CB2725 |
| S1 | 3101-0036 | 1 | 1 | SWITCH-TGL BASIC SPST 3A 250VAC/DC | 28480 | 3101-0036 |
| S2 | 3101-1234 | 3 | 1 | SWITCH-SL DPDT STD 1.5A 250VAC SLDR-LUG | 28480 | 3101-1234 |
| S301 | 3100-0358 | 8 | 1 | SWITCH-ROTARY 1.250 STRUT CTR SPCB; 12 | 28480 | 3100-0358 |
| T1 | 9100-4248 | 9 | 1 | TRANSFORMER-POWER (SEE NOTE BELOW) | 28480 | 9100-4248 |
| TC401 | 0853-0003 | 2 | 2 | THERMOCOUPLE-PR. | 28480 | 0853-0003 |
| TC402 | 0853-0003 | 2 | 2 | THERMOCOUPLE-PR. | 28480 | 0853-0003 |
| U601 | 1826-0968 | 2 | 1 | IC-OPERATIONAL AMPLIFIER | 28480 | 1826-0968 |
| U602 | 1826-0310 | 8 | 1 | IC-OPERATIONAL AMPLIFIER | 28480 | 1826-0310 |
| V201 | 1921-0017 | 4 | 1 | TUBE-ELECTRON 7586 TRIODE | 3LS85 | 7586 |
| W1 | 8120-1348 | 5 | 1 | CABLE ASSY 18AWG 3-CNDCT BLK-JKT | 28480 | 8120-1348 |
| XF1 | 1400-0084 | 1 | 1 | FUSEHOLDER-EXTR POST 15A 250 V UL | 28480 | 1400-0084 |
| XV201 | 1200-0086 | 9 | 1 | SOCKET-TUBE 5-CONT ES-6S DIP-SLDR | 28480 | 1200-0086 |
| | 1200-0044 | 9 | 2 | SOCKET-XSTR 2-CONT TO-3 | 28480 | 1200-0044 |
| | | | | MISCELLANEOUS | | |
| | 0370-0077 | 4 | 1 | KNOB SHRTD BAR;BLK;FOR .250SHFT; .625D | 28480 | 0370-0077 |
| | 0340-0580 | 3 | 1 | INSULATOR-XSTR | 28480 | 0340-0580 |
| | 1520-0002 | 7 | 1 | PLATE-MOUNTING FOR TWIST LOCK TYPE CAP | 28480 | 1520-0002 |
| | 1520-0003 | 8 | 1 | PLATE-MOUNTING FOR TWIST LOCK TYPE CAP | 28480 | 1520-0003 |
| | 03400-01202 | 2 | 1 | CLAMP-CAPACITOR MOUNTING | 28480 | 03400-01202 |
| | 03400-01204 | 4 | 1 | BRACKET-GROUND | 28480 | 03400-01204 |
| | 03400-61601 | 1 | 1 | CABLE ASSEMBLY-AMPLIFIER INPUT | 28480 | 03400-61601 |
| | 03400-61602 | 2 | 1 | CABLE ASSEMBLY-CHOPPER INPUT | 28480 | 03400-61602 |
| | 03400-61603 | 3 | 1 | CABLE ASSEMBLY-INPUT ATTENUATOR | 28480 | 03400-61603 |
| | 03400-69501 | 6 | 1 | SHOCK MOUNT IMPEDANCE CONVERTER | 28480 | 03400-69501 |
| | 1200-0044 | 9 | 1 | SOCKET-XSTR 2-CONT TO-3 | 28480 | 1200-0044 |

NOTE: SOME INSTRUMENTS HAVE POWER TRANSFORMERS (T1) WITH -HP- PART NUMBER 9100-4449. REPLACE WITH NEW PART NUMBER.

See introduction to this section for ordering information
*Indicates factory selected value



3400-A-1

Figure A-1. Chopper Amplifier A6 and Thermocouple Pair (Part of A4) Schematic and Parts Location Diagram A-1

Product Line Sales/Support Key

Key Product Line
 A Analytical
 CM Components
 C Computer Systems Sales only
 CH Computer Systems Hardware Sales and Services
 CS Computer Systems Software Sales and Services
 E Electronic Instruments & Measurement Systems
 M Medical Products
 MP Medical Products Primary SRO
 MS Medical Products Secondary SRO
 P Personal Computation Products
 * Sales only for specific product line
 ** Support only for specific product line

IMPORTANT: These symbols designate general product line capability. They do not insure sales or support availability for all products within a line, at all locations. Contact your local sales office for information regarding locations where HP support is available for specific products.

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 Tel: 0732 51585
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Hewlett-Packard (Canada) Ltd.
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 MONCTON, New Brunswick E2B 2VQ
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CHINA, People's Republic
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 1A Lane 2, Luchang St.
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Instrumentación
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28 Rue de la Republique
F-25000 BESANCON
Tel: (81) 83-16-22
CH,M

Hewlett-Packard France
Bureau de Vente de Lyon
Chemin des Mouilles
Boite Postale 162
F-69130 ECULLY Cédex
Tel: (78) 33-81-25
Telex: 310817F
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Hewlett-Packard France
Immeuble France Evry
Tour Lorraine
Boulevard de France
F-91035 EVRY Cédex
Tel: (60) 77-96-60
Telex: 692315F
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Bâtiment Ampère 5 étage
Rue de la Commune de Paris
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Avenue du President JF Kennedy
F-33700 MERIGNAC
Tel: (56) 34-00-84
Telex: 550105F
CH,CM,E,MS

Hewlett-Packard France
32 Rue Lothaire
F-57000 METZ
Tel: (87) 65-53-50
CH,CM

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F-44200 NANTES
Tel: 40-89-33-38
CH**

Hewlett-Packard France
Zone Industrielle de Courtaboeuf
Avenue des Tropiques
F-91947 Les Ulis Cédex ORSAY
Tel: (6) 907-78-25
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Hewlett-Packard France
Paris Porte-Maillot
13, 15 25 Bld. De L'Amiral Bruix
F-75782 PARIS Cédex 16
Tel: (01) 502-12-20
Telex: 613663F
CH,CM,MS,P

Hewlett-Packard France
Technisches Büro Neulm
F-35100 RENNES
Tel: (99) 51-42-44
Telex: 740912F
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Hewlett-Packard France
98 Avenue de Bretagne
F-78100 ROUEN
Tel: (35) 63-57-66 CH** ,CS

Hewlett-Packard France
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Boite Postale 56
F-67200 STRASBOURG
Tel: (88) 28-56-46
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20 Chemin de la Cèpière
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Immeuble Péricentre
Rue Van Gogh
F-59650 VILLENEUVE D'ASO
Tel: (20) 91-41-25
Telex: 160124F
CH,CM,E,MS,P*

GERMAN FEDERAL REPUBLIC

Hewlett-Packard GmbH
Technisches Büro Berlin
Keilstrasse 2-4
D-1000 BERLIN 30
Tel: (030) 24-90-86
Telex: 018 3405 hpbld
A,CH,CM,E,M,P,X

Hewlett-Packard GmbH
Technisches Büro Böblingen
Herrnberger Strasse 110
D-7030 BOBLINGEN
Tel: (07031) 667-1
Telex: bbn or
A,CH,CM,CS,E,MP,P

Hewlett-Packard GmbH
Technisches Büro Dusseldorf
Emanuel-Leutze-Strasse 1
D-4000 DUSSELDORF
Tel: (0211) 5971-1
Telex: 085/86 533 hpdd
A,CH,CM,CS,E,MS,P

Hewlett-Packard GmbH
Vertriebszentrale Frankfurt
Bernar Strasse 117
Postfach 560 140
D-5000 FRANKFURT 56
Tel: (0511) 50-04-1
Telex: 04 13249 hpffm
A,CH,CM,CS,E,MP,P

Hewlett-Packard GmbH
Technisches Büro Hamburg
Kapstadtring 5
D-2000 HAMBURG 60
Tel: (040) 63804-1
Telex: 021 63 032 hphd
A,CH,CM,CS,E,MS,P

Hewlett-Packard GmbH
Technisches Büro Hannover
Am Grossmarkt 6
D-3000 HANNOVER 91
Tel: (0511) 46-60-01
Telex: 092 3259
A,CH,CM,E,MS,P

Hewlett-Packard GmbH
Technisches Büro Mannheim
Rossauer Weg 2-4
D-6800 MANNHEIM
Tel: (0621) 70050
Telex: 0462105
A,C,E

Hewlett-Packard GmbH
Technisches Büro Neu Ulm
Messerschmittstrasse 7
D-7910 NEU ULM
Tel: 0731-70241
Telex: 07 12816 HP ULM-D
A,C,E*

Hewlett-Packard GmbH
Technisches Büro Nürnberg
Neumeyerstrasse 90
D-8500 NÜRNBERG
Tel: (0911) 52 20 83-87
Telex: 0623 860
CH,CM,E,MS,P

Hewlett-Packard GmbH
Technisches Büro München
Eschenstrasse 5
D-8028 TAUFKIRCHEN
Tel: (089) 6117-1
Telex: 0524985
A,CH,CM,E,MS,P

GREAT BRITAIN

Hewlett-Packard Ltd.
Trafalgar House
Navigation Road
ALTRINCHAM
Cheshire WA14 1NU
Tel: (061) 928-6422
Telex: 668068
A,CH,CS,E,M

Hewlett-Packard Ltd.
Oakfield House, Oakfield Grove
Clifton
BRISTOL BS8 2BN, Avon
Tel: (027) 38606
Telex: 444302
CH,CM,M,P

Hewlett-Packard Ltd.
14 Wesley Street
CASTLEFORD
Yorkshire WF10 1AE
Tel: (0977) 550016
Telex: 5557355
CH

Hewlett-Packard Ltd.
Nine Mile Ride
EASTHAMPTON
Wokingham
Berkshire, RG11 3LL
Tel: 3446 3100
Telex: 84-88-05
CH,CS,E

Hewlett-Packard Ltd.
Fouier House
257-263 High Street
LONDON COLNEY
Herts., AL2 1HA, St. Albans
Tel: (0727) 24400
Telex: 1-8952716
CH,CS,E

Hewlett-Packard Ltd.
Tradax House, St. Mary's Walk
MAIDENHEAD
Berkshire, SL6 1ST
Tel: (0628) 39151
CH,CS,E,P

Hewlett-Packard Ltd.
Quadrangle
106-118 Station Road
REDHILL, Surrey
Tel: (0737) 86655
Telex: 947234 CH,CS,E

Hewlett-Packard Ltd.
Westminster House
190 Stratford Road
SHIRLEY, Solihull
West Midlands B90 3BJ
Tel: (021) 7458800
Telex: 339105
CH

Hewlett-Packard Ltd.
West End House 41
High Street, West End
SOUTHAMPTON
Hampshire SO3 3DO
Tel: (703) 888767
Telex: 477138
CH

Hewlett-Packard Ltd.
King Street Lane
WINNERSH, Wokingham
Berkshire RG11 5AR
Tel: (0734) 784774
Telex: 847178
A,CH,E,M

GREECE

Kostas Karayannis S.A.
8 Omirou Street
ATHENS 133
Tel: 32-30-303, 32-37-371
Telex: 21 59 62 FKAR GR
A,CH,CM,CS,E,M,P

PLAISIO S.A.
G. Gerardos
24 Stourmara Street
ATHENS
Tel: 36-11-160
Telex: 21 9492
P

GUATEMALA

IPESA
Avenida Reforma 3-48, Zona 9
GUATEMALA
Tel: 316627, 314786
Telex: 4192 TELTRO GU
A,CH,CM,CS,E,M,P

HONG KONG

Hewlett-Packard Hong Kong, Ltd.
G.P.O. Box 795
5th Floor, Sun Hung Kai Centre
30 Harbour Road
HONG KONG
Tel: 5-8323211
Telex: 66678 HEWPA HK
Cable: HP ASIA LTD Hong Kong
E,CH,CS,P

CET Ltd.
1402 Tung Way Mansion
199-203 Hennessy Rd.
Wanchia, HONG KONG
Tel: 5-729376
Telex: 85148 CET HX
CM

Schmidt & Co. (Hong Kong) Ltd.
Wing On Centre, 28th Floor
Connaught Road, C.
HONG KONG
Tel: 5-455644
Telex: 74766 SCHMX HX
A,M

ICELAND

Elding Trading Company Inc.
Háinnarvöll-Tryggvagatou
P.O. Box 895
IS-REYKJAVIK
Tel: 1-58-20, 1-63-03
M

INDIA

Blue Star Ltd.
Sabri Complex II Floor
24 Residency Rd.
BANGALORE 560 025
Tel: 55660
Telex: 0845-430
Cable: BLUESTAR
A,CH,CM,CS,E

Blue Star Ltd.
Band Box House
Prabhadevi
BOMBAY 400 025
Tel: 422-3101
Telex: 011-3751
Cable: BLUESTAR
A,M

Blue Star Ltd.
Sahas
414/2 Vir Savarkar Marg
Prabhadevi
BOMBAY 400 025
Tel: 422-6155
Telex: 011-4093
Cable: FROSTBLUE
A,CH,CM,CS,E,M

Blue Star Ltd.
Kalyan, 19 Vishwas Colony
Alkapuri, BORODA, 390 005
Tel: 65235
Cable: BLUE STAR
A

Blue Star Ltd.
7 Hare Street
CALCUTTA 700 001
Tel: 12-01-31
Telex: 021-7655
Cable: BLUESTAR
A,M

Blue Star Ltd.
133 Kodambakkam High Road
MADRAS 500 034
Tel: 82057
Telex: 041-379
Cable: BLUESTAR
A,M

Blue Star Ltd.
Bhandari House, 7th/8th Floors
91 Nehru Place
NEW DELHI 110 024
Tel: 682547
Telex: 031-2463
Cable: BLUESTAR
A,CH,CM,CS,E,M

Blue Star Ltd.
15/16-C Wellesley Rd.
PUNE 411 011
Tel: 22775
Cable: BLUE STAR
A

Blue Star Ltd.
2-2-47/1108 Polarum Rd.
SECUNDERABAD 500 003
Tel: 72057
Telex: 0155-459
Cable: BLUEFROST
A,E

Blue Star Ltd.
T.C. 7/603 Poornima
Maruthankuzhi
TRIVANDRUM 695 013
Tel: 65799
Telex: 0884-259
Cable: BLUESTAR
E

INDONESIA

BERCA Indonesia P.T.
P.O.Box 496/JKT.
J. Abdul Muis 62
JAKARTA
Tel: 373009
Telex: 46748 BERSAL IA
Cable: BERSAL JAKARTA
P

SALES & SUPPORT OFFICES

Arranged alphabetically by country

3



INDONESIA (Con't.)

BERCA Indonesia P.T.
Wisma Antara Bldg., 17th floor
JAKARTA
A,CS,E,M

BERCA Indonesia P.T.
P.O. Box 174/SBY,
Jl. Kulei No. 11
SURABAYA
Tel: 68172

Telex: 31146 BERSAL SB
Cable: BERSAL-SURABAYA
A*,E,M,P

IRAQ

Hewlett-Packard Trading S.A.
Mansoor City 9B/3/7
BAGHDAD
Tel: 551-49-73
Telex: 212-455 HEPARAO IK
CH,CS

IRELAND

Hewlett-Packard Ireland Ltd.
Kestrel House
Clanwilliam Court
Lower Mount Street
DUBLIN 2, Eire
Tel: (1) 60 88 00
Telex: 30439
A,CH,CM,CS,E,M,P
Cardiac Services Ltd.
Kilmore Road
Artane
DUBLIN 5, Eire
Tel: (01) 351820
Telex: 30439
M

ISRAEL

Electronics Engineering Division
Motorola Israel Ltd.
16 Kremnetski Street
P.O. Box 25016
TEL-AVIV 67899
Tel: 3-338973
Telex: 33569 Motil IL
Cable: BASTEL Tel-Aviv
A,CH,CM,CS,E,M,P

ITALY

Hewlett-Packard Italiana S.p.A.
Traversa 99C
Giulio Petrone, 19
I-70124 BARI
Tel: (080) 41-07-44
M

Hewlett-Packard Italiana S.p.A.
Via Martin Luther King, 38/111
I-40132 BOLOGNA
Tel: (051) 402394
Telex: 511630
CH,CM,E,MS

Hewlett-Packard Italiana S.p.A.
Via Principe Nicola 43G/C
I-95126 CATANIA
Tel: (095) 37-10-87
Telex: 970291
C,P

Hewlett-Packard Italiana S.p.A.
Via G. Di Vittorio 9
I-20063 CERNUSCO SUL NAVIGLIO
Tel: (2) 903691
Telex: 334632
A,CH,CM,CS,E,MP,P

Hewlett-Packard Italiana S.p.A.
Via Nuova san Rocco A
Capodimonte, 62/A
I-80131 NAPLES
Tel: (081) 7413544
Telex: 710698
A,CH,CM,E

Hewlett-Packard Italiana S.p.A.
Viale G. Modugno 33
I-16156 GENOVA FEGLI
Tel: (010) 68-37-07
E,C

Hewlett-Packard Italiana S.p.A.
Via Turazza 14
I-35100 PADOVA
Tel: (049) 864888
Telex: 430315
A,CH,CM,E,MS

Hewlett-Packard Italiana S.p.A.
Viale C. Pavese 340
I-00144 ROMA
Tel: (06) 54831
Telex: 610514
A,CH,CM,CS,E,MS,P*

Hewlett-Packard Italiana S.p.A.
Corso Svizzera, 184
I-10149 TORINO
Tel: (011) 74 4044
Telex: 221079
CH,CM,E

JAPAN

Yokogawa-Hewlett-Packard Ltd.
Inoue Building
1-21-8, Asahi-cho
ATSUGI, Kanagawa 243
Tel: (0462) 28-0451
CM,C*,E

Yokogawa-Hewlett-Packard Ltd.
Sannomiya Dai-ichi Seimei Bldg.
69 Kyo-machi, Chuo-ku
KOBE, 650
Tel: (078) 392-4791
C,E

Yokogawa-Hewlett-Packard Ltd.
Kumagaya Asahi Yasoji Bldg 4F
3-4 Chome Tsukuba
KUMAGAYA, Saitama 360
Tel: (0485) 24-6563
CH,CM,E

Yokogawa-Hewlett-Packard Ltd.
Asahi Shinbun Dai-ichi Bldg., 2F
4-7 Hanabata-cho
KUMAMOTO-SHI, 860
Tel: (0963) 54-7311
CH,E

Yokogawa-Hewlett-Packard Ltd.
Shin Kyoto Center Bldg. 5F
614 Sio-koji-cho
Nishiurugashi, Karasuma
Sio-koji-don, Shimogyo-ku
KYOTO 600
Tel: 075-343-0921
CH,E

Yokogawa-Hewlett-Packard Ltd.
Mito Mitsui Building
1-4-73, San-no-maru
MITO, Ibaragi 310
Tel: (0292) 25-7470
CH,CM,E

Yokogawa-Hewlett-Packard Ltd.
Sumitomo Seimei Nagoya Bldg.
11-2 Shimo-sasajima-cho
Nakamura-ku
NAGOYA, Aichi 450
Tel: (052) 571-5171
CH,CM,CS,E,MS

Yokogawa-Hewlett-Packard Ltd.
Chuo Bldg., 4th Floor
5-4-20 Nishinakajima
Yodogawa-ku
OSAKA, 532
Tel: (06) 304-6021
Telex: YHPOSA 523-3624
A,CH,CM,CS,E,MP,P*

Yokogawa-Hewlett-Packard Ltd.
27-15, 1-chome
Yabe
SAGAMIHARA-SHI PREF. 229
Tel: 427-591311
Telex: 8912
CH*,E*,P*

Yokogawa-Hewlett-Packard Ltd.
Shinjuku Dai-ichi Seimei 5F
2-7-1, Nishi Shinjuku
Shinjuku-ku, TOKYO 160
Tel: 03-348-4611-5
CH,E

Yokogawa-Hewlett-Packard Ltd.
3-29-21 Takaido-Higashi
Suginami-ku TOKYO 168
Tel: (03) 331-6111
Telex: 232-2024 YHPTOK
A,CH,CM,CS,E,MP,P*

Yokogawa-Hewlett-Packard Ltd.
Yasudaseimei Yokohama
Nishiguchi Bldg.
3-304 Tsuruya-cho
Kanagawa-ku
YOKOHAMA, Kanagawa, 221
Tel: (045) 312-1252
CH,CM,E

JORDAN

Mouasher Cousins Company
P.O. Box 1387
AMMAN
Tel: 24907, 39907
Telex: 21456 SABCO JO
CH,E,M,P

KENYA

ADCOM Ltd., Inc.
City House, Wabera Street
P.O. Box 30635
NAIROBI
Tel: 331955
Telex: 22639
E,M

KOREA

Samsung Electronics Computer
Division
76-561 Yeoksam-Dong
Kangnam-ku
C.P.O. Box 2775
SEOUL
Tel: 555-7555, 555-5447
Telex: K27364 SAMSAN
A,CH,CM,CS,E,M,P

Yokogawa-Hewlett-Packard Ltd.
Shin Kyoto Center Bldg. 5F
614 Sio-koji-cho
Nishiurugashi, Karasuma
Sio-koji-don, Shimogyo-ku
KYOTO 600
Tel: 075-343-0921
CH,E

Yokogawa-Hewlett-Packard Ltd.
Mito Mitsui Building
1-4-73, San-no-maru
MITO, Ibaragi 310
Tel: (0292) 25-7470
CH,CM,E

Yokogawa-Hewlett-Packard Ltd.
Sumitomo Seimei Nagoya Bldg.
11-2 Shimo-sasajima-cho
Nakamura-ku
NAGOYA, Aichi 450
Tel: (052) 571-5171
CH,CM,CS,E,MS

Yokogawa-Hewlett-Packard Ltd.
Chuo Bldg., 4th Floor
5-4-20 Nishinakajima
Yodogawa-ku
OSAKA, 532
Tel: (06) 304-6021
Telex: YHPOSA 523-3624
A,CH,CM,CS,E,MP,P*

Yokogawa-Hewlett-Packard Ltd.
27-15, 1-chome
Yabe
SAGAMIHARA-SHI PREF. 229
Tel: 427-591311
Telex: 8912
CH*,E*,P*

Yokogawa-Hewlett-Packard Ltd.
Shinjuku Dai-ichi Seimei 5F
2-7-1, Nishi Shinjuku
Shinjuku-ku, TOKYO 160
Tel: 03-348-4611-5
CH,E

Yokogawa-Hewlett-Packard Ltd.
3-29-21 Takaido-Higashi
Suginami-ku TOKYO 168
Tel: (03) 331-6111
Telex: 232-2024 YHPTOK
A,CH,CM,CS,E,MP,P*

Yokogawa-Hewlett-Packard Ltd.
Yasudaseimei Yokohama
Nishiguchi Bldg.
3-304 Tsuruya-cho
Kanagawa-ku
YOKOHAMA, Kanagawa, 221
Tel: (045) 312-1252
CH,CM,E

Protel Engineering
Lot 319, Satok Road
P.O. Box 1917
Kuching, SARAWAK
Tel: 53544
Telex: MA 70904 PROMAL
Cable: PROTELENG
A,E,M

MALTA

Philip Toledo Ltd.
Natabile Rd.
MRIEHEL
Tel: 447 47, 455 66
Telex: MW.649
P

MEXICO

Hewlett-Packard Mexicana, S.A. de
C.V.
Av. Periferico Sur No. 6501
Tepepan, Xochimilco 16020
MEXICO CITY
Tel: (905) 676-4600
Telex: 017-74-507
A,CH,CS,E,MS,P

Hewlett-Packard Mexicana, S.A. de
C.V.
Rio Volga 600
Colonia del Valle
MONTERREY, N.L.
Tel: 78-42-93, 78-42-40, 78-42-41
Telex: 038-410
CH

ECISA
Taine 229 10 Pisa
Polanco D.F.
C.P. 11570
Tel: (905) 250-5391
M

MOROCCO

Doibau
81 rue Karatchi
CASABLANCA
Tel: 3041-82, 3068-38
Telex: 23051, 22822
E

Gerep
2 rue d'Agadir
Boite Postale 156
CASABLANCA
Tel: 272093, 272095
Telex: 23 739
P

NETHERLANDS

Hewlett-Packard Nederland B.V.
Van Heuven Goedhartlaan 121
NL 1181KK AMSTELVEEN
P.O. Box 667
NL 1180 AR AMSTELVEEN
Tel: (20) 47-20-21
Telex: 13 216
A,CH,CM,CS,E,MP,P

Hewlett-Packard Nederland B.V.
Bongerd 2
NL 2906VK CAPPELLE, A/D IJssel
P.O. Box 41
NL 2900 AA CAPELLE, IJssel
Tel: (10) 51-64-44
Telex: 21261 HEPAC NL
A,CH,CM,CS

Koning en Hartman Electrotechniek
B.V.
Koperwerf 30
2544 En den Haag
The NETHERLANDS
Tel: 070-210101
Telex: 31528
CM

NEW ZEALAND

Hewlett-Packard (N.Z.) Ltd.
169 Manukau Road
P.O. Box 26-189
Epsom, AUCKLAND
Tel: 687-159
Cable: HEWPACK Auckland
CH,CM,E,P*

Hewlett-Packard (N.Z.) Ltd.
4-12 Cruickshank Street
Kilbirnie, WELLINGTON 3
P.O. Box 9443
Courtenay Place, WELLINGTON 3
Tel: 877-199
Cable: HEWPACK Wellington
CH,CM,E,P

Northrop Instruments & Systems
Ltd.

369 Khyber Pass Road
P.O. Box 8602

AUCKLAND

Tel: 794-091

Telex: 60605

A,M

Northrop Instruments & Systems
Ltd.

110 Mandeville St.

P.O. Box 8388

CHRISTCHURCH

Tel: 486-928

Telex: 4203

A,M

Northrop Instruments & Systems
Ltd.

Sturdee House

85-87 Ghuznee Street

P.O. Box 2406

WELLINGTON

Tel: 850-091

Telex: NZ 3380

A,M

NORTHERN IRELAND

Cardiac Services Company
95A Finaghy Road South
BELFAST BT 10 0BY
Tel: (0232) 625-566
Telex: 747626
M

NORWAY

Hewlett-Packard Norge A/S
Folke Bemadotiesvei 50
P.O. Box 3558
N-5033 FYLLINGSDALEN (BERGEN)
Tel: (05) 16-55-40
Telex: 16621 hpnas n
CH,CM,E

Hewlett-Packard Norge A/S
Oestermdalen 18
P.O. Box 34
N-1345 OSTERAS
Tel: (02) 17-11-80
Telex: 16821 hpnas n
A*,CM,E,MS,P

OMAN

Khimji Ramdas
P.O. Box 19
MUSCAT
Tel: 72-22-17, 72-22-25
Telex: 3289 BROKER MB MUSCAT
P

PAKISTAN

Mushko & Company Ltd.
1-B, Street 43
Sector F-8/1
ISLAMABAD
Tel: 26875
Cable: FEMUS Rawalpindi
A,E,M



SALES & SUPPORT OFFICES

Arranged alphabetically by country

PAKISTAN (Con't.)

Musko & Company Ltd.
Oosman Chambers
Abdullah Haroon Road
KARACHI 0302
Tel: 511027, 512927
Telex: 2894 MUSKO FK
Cable: COOPERATOR Karachi
A,E,M,P*

PANAMA

Electrónico Balboa, S.A.
Calle Samuel Lewis, Ed. Alfa
Apartado 4929
PANAMA 5
Tel: 64-2700
Telex: 3438 ELECTRON PG
A,C,M,E,M,P
Foto Internacional, S.A.
Colon Free Zone, Apartado 2068
COLON 3
Tel: 45-2333
Telex: 379 8626, IMPORT PG
P

PERU

Cia Electro Médica S.A.
Los Flamencos 145, San Isidro
Casilla 1030
LIMA 1
Tel: 41-4325, 41-3703
Telex: Pub. Booth 25306
A,C,M,E,M,P

PHILIPPINES

The Online Advanced Systems
Corporation
Rico House, Amorsolo Cor. Herrera
Street
Legaspi Village, Makail
P.O. Box 1510
Metro MANILA
Tel: 85-35-81, 85-34-91, 85-32-21
Telex: 3274 ONLINE
A,C,H,CS,E,M
Electronic Specialists and
Proponents Inc.
690-B Epifanio de los Santos
Avenue
Cubao, QUEZON CITY
P.O. Box 2649 Manila
Tel: 98-96-81, 98-96-82, 98-96-83
Telex: 40018, 42000 ITT GLOBE
MACKAY BOOTH
P

POLAND

Buro Informacji Technicznej
Hewlett-Packard
Ul Stawki 2, 6P
PŁO-950 WARSZAWA
Tel: 39-59-62, 39-67-43
Telex: 812453 hepa pl

PORTUGAL

Telectra-Empresa Técnica de
Equipamentos Eléctricos S.a.r.l.
Rua Rodrigo da Fonseca 103
P.O. Box 2531
P-LISBON 1
Tel: (19) 68-60-72
Telex: 12598
CH,CS,E,P
Mundinter
Intercambio Mundial de Comércio
S.a.r.l.
P.O. Box 2761
Avenida Antonio Augusto de Aguiar
138
P-LISBON
Tel: (19) 53-21-31, 53-21-37
Telex: 16691 munter p
M

PUERTO RICO

Hewlett-Packard Puerto Rico
P.O. Box 4407
CAROLINA, Puerto Rico 00630
Calle 272 Edificio 203
Urb. Country Club
RIO PIEDRAS, Puerto Rico 00924
Tel: (809) 762-7255
Telex: 345 0514
A,CH,CS

QATAR

Nasser Trading & Contracting
P.O. Box 1563
DOHA
Tel: 22170
Telex: 4439 NASSER
M
Computerbia
P.O. Box 2570
DOHA
Tel: 329515
Telex: 4806 CHPARB
P

ROMANIA

Hewlett-Packard Reprezentanta
Boulevard Nicolae Balcescu 16
BUCURESTI
Tel: 130725
Telex: 10440

SAUDI ARABIA

Modern Electronic Establishment
P.O. Box 193
AL-KHOBAR
Tel: 864-4678
Telex: 670136
Cable: ELECTA AL-KHOBAR
CH,CS,E,M,P
Modern Electronic Establishment
P.O. Box 1228, Baghdadiah Street
JEDDAH
Tel: 642-0229
Telex: 401035
Cable: ELECTA JEDDAH
CH,CS,E,M,P
Modern Electronic Establishment
P.O. Box 2728
RIYADH
Tel: 491-9715, 491-6387
Telex: 200756
CH,CS,E,M,P

SCOTLAND

Hewlett-Packard Ltd.
Royal Bank Buildings
Swan Street
BRECHIN, Angus, Scotland
Tel: (03562) 3101-2
CH,CM
Hewlett-Packard Ltd.
SOUTH QUEENSFERRY
West Lothian, EH30 9GT
GB-Scotland
Tel: (031) 331188
Telex: 72682
A,CH,CM,CS,E,M

SINGAPORE

Hewlett-Packard Singapore (Pty.)
Ltd.
P.O. Box 58 Alexandra Post Office
SINGAPORE, 9115
6th Floor, Inchange House
450-452 Alexandra Road
SINGAPORE 0511
Tel: 631788
Telex: HPSGSD RS 34209
Cable: HEWPACK, Singapore
A,CH,CS,E,MS,P
Dynamar International Ltd.
Unit 05-11 Block 6
Kolam Ayer Industrial Estate
SINGAPORE 1334
Tel: 747-6188
Telex: RS26283
CM

SOUTH AFRICA

Hewlett-Packard South Africa (Pty.)
Ltd.
P.O. Box 120
Howard Place
Pine Park Center, Forest Drive,
Pinelands
CAPE PROVINCE 7450
Tel: 53-7955, 53-7956, 53-7957
Telex: 57-20006
A,CH,CM,E,MS,P
Hewlett-Packard South Africa (Pty.)
Ltd.
P.O. Box 37099
Overport
DURBAN 4067
Tel: 28-4178, 28-4179, 28-4110
Telex: 6-22954
CH,CM
Hewlett-Packard South Africa (Pty.)
Ltd.
P.O. Box 33345
Glenstantia 0010 TRANSVAAL
1st Floor East
Constantia Park Ridge Shopping
Centre
Constantia Park
PRETORIA
Tel: 982043
Telex: 32163
CH,E
Hewlett-Packard South Africa (Pty.)
Ltd.
Private Bag Wendywood
SANDTON 2144
Tel: 802-5111, 802-5125
Telex: 4-20877
Cable: HEWPACK Johannesburg
A,CH,CM,CS,E,MS,P

SWITZERLAND

Hewlett-Packard (Schweiz) AG
Clarastrasse 12
CH-4058 BASLE
Tel: (61) 33-59-20
A,CM
Hewlett-Packard (Schweiz) AG
Bahnhofweg 44
3018 BERN
Tel: (031) 56-24-22
CH,CM
Hewlett-Packard (Schweiz) AG
47 Avenue Blanc
CH-1202 GENEVA
Tel: (022) 32-48-00
CH,CM,CS
Hewlett-Packard (Schweiz) AG
29 Chemin Château Bloc
CH-1219 LE LIGNON-Geneva
Tel: (022) 96-03-22
Telex: 27333 hpag ch
Cable: HEWPACKAG Geneva
A,CM,E,MS,P
Hewlett-Packard (Schweiz) AG
Allmend 2
CH-8967 WIDEN
Tel: (57) 50-111
Telex: 59933 hpag ch
Cable: HPAG CH
A,CH,CM,CS,E,MS,P

SPAIN

Hewlett-Packard Española S.A.
c/Entenza, 321
E-BARCELONA 29
Tel: (3) 322-24-51, 321-73-54
Telex: 52603 hpbee
A,CH,CM,CS,E,MS,P
Hewlett-Packard Española S.A.
c/San Vicente S/N
Edificio Albia II,7 B
E-BILBAO 1
Tel: (4) 23-8306, (4) 23-8206
A,CH,CM,E,MS
Hewlett-Packard Española S.A.
Calle Jerez 3
E-MADRID 16
Tel: (1) 458-2600
Telex: 23515 hpe
A,CM,E
Hewlett-Packard Española S.A.
c/o Costa Brava 13
Colonia Mirasierra
E-MADRID 34
Tel: (1) 734-8061, (1) 734-1162
CH,CS,M
Hewlett-Packard Española S.A.
Av Ramón y Cajal 1-9
Edificio Sevilla 1,
E-SEVILLA 5
Tel: 64-44-54, 64-44-58
Telex: 72933
A,CM,CS,MS,P
Hewlett-Packard Española S.A.
C/Ramón Gordillo, 1 (Entlo.3)
E-VALENCIA 10
Tel: 361-1354, 361-1358
CH,CM,P

SWEDEN

Hewlett-Packard Sverige AB
Sunnanvagen 14K
S-22228 LUND
Tel: (046) 13-69-79
Telex: (854) 10721 (via SPANGA
office)
CH,CM

Hewlett-Packard Sverige AB
Vastra Vintergatan 9
S-70344 ÖREBRO
Tel: (19) 10-48-80
Telex: (854) 10721 (via SPANGA
office)
CH,CM
Hewlett-Packard (Schweiz) AG
Skalholtsgatan 9, Kista
Box 19
S-16393 SPANGA
Tel: (08) 750-2000
Telex: 854-10721
A,CH,CM,CS,E,MS,P
Hewlett-Packard Sverige AB
Fröfallsgratan 30
S-42132 VÄSTRA-FRÖLUNDA
Tel: (031) 49-09-50
Telex: (854) 10721 (via SPANGA
office)
CH,CM,E,P

THAILAND

Hewlett-Packard Far East Ltd.
Taiwan Branch
5th Floor
205 Tun Hwa North Road
TAIPEI
Tel:(02) 751-0404
Cable:HEWPACK Taipei
A,CH,CM,CS,E,M,P
Ing Lih Trading Co.
3rd Floor 18, Po-Ai Road
TAIPEI 100
Tel: (02) 3111914
Cable: INGLIH TAIPEI
A
THAILAND
Unimesa
30 Paipong Ave., Suriwong
BANGKOK 5
Tel: 234 091, 234 092
Telex: 84439 Simonco TH
Cable: UNIMESA Bangkok
A,C,E,M
Bangkok Business Equipment Ltd.
5/5-6 Dejo Road
BANGKOK
Tel: 234-8670, 234-8671
Telex: 87669-BEQUIPT TH
Cable: BUSIQUIPT Bangkok
P

SWITZERLAND
Hewlett-Packard (Schweiz) AG
Clarastrasse 12
CH-4058 BASLE
Tel: (61) 33-59-20
A,CM
Hewlett-Packard (Schweiz) AG
Bahnhofweg 44
3018 BERN
Tel: (031) 56-24-22
CH,CM
Hewlett-Packard (Schweiz) AG
47 Avenue Blanc
CH-1202 GENEVA
Tel: (022) 32-48-00
CH,CM,CS
Hewlett-Packard (Schweiz) AG
29 Chemin Château Bloc
CH-1219 LE LIGNON-Geneva
Tel: (022) 96-03-22
Telex: 27333 hpag ch
Cable: HEWPACKAG Geneva
A,CM,E,MS,P
Hewlett-Packard (Schweiz) AG
Allmend 2
CH-8967 WIDEN
Tel: (57) 50-111
Telex: 59933 hpag ch
Cable: HPAG CH
A,CH,CM,CS,E,MS,P

SYRIA

General Electronic Inc.
Nuri Basha-Ahmad Ebn Kays Street
P.O. Box 5781
DAMASCUS
Tel: 33-24-87
Telex: 11215 ITIKAL
Cable: ELECTROBOR DAMASCUS
E
Middle East Electronics
Place Azmé
Boite Postale 2308
DAMASCUS
Tel: 334592
Telex: 11304 SATACO SY
M,P

TAIWAN

Hewlett-Packard Far East Ltd.
Kachsiung Office
2/F 68-2, Chung Cheng 3rd Road
KAOHSIUNG
Tel: 241-2318, 261-3253
CH,CS
Hewlett-Packard Far East Ltd.
Taichung Office
#33, Cheng Yi Rd.
10th Floor, Room 5
TAICHUNG
Tel: (042) 289274

Hewlett-Packard Far East Ltd.
Taiwan Branch
5th Floor
205 Tun Hwa North Road
TAIPEI
Tel:(02) 751-0404
Cable:HEWPACK Taipei
A,CH,CM,CS,E,M,P
Ing Lih Trading Co.
3rd Floor 18, Po-Ai Road
TAIPEI 100
Tel: (02) 3111914
Cable: INGLIH TAIPEI
A

THAILAND

Unimesa
30 Paipong Ave., Suriwong
BANGKOK 5
Tel: 234 091, 234 092
Telex: 84439 Simonco TH
Cable: UNIMESA Bangkok
A,C,E,M
Bangkok Business Equipment Ltd.
5/5-6 Dejo Road
BANGKOK
Tel: 234-8670, 234-8671
Telex: 87669-BEQUIPT TH
Cable: BUSIQUIPT Bangkok
P

TRINIDAD & TOBAGO

Caribbean Telecoms Ltd.
50A Jerningham Avenue
P.O. Box 732
PORT-OF-SPAIN
Tel: 62-44213, 62-44214
Telex: 235,272 HUGCO WG
A,C,M,E,M,P

TUNISIA

Tunisie Electronique
31 Avenue de la Liberté
TUNIS
Tel: 280-144
E,P
Corema
1 ter. Av. de Carthage
TUNIS
Tel: 253-821
Telex: 12319 CABAM TN
M

TURKEY

Teknim Company Ltd.
Iran Caddesi No.7
Kavaklıdere, ANKARA
Tel: 275900
Telex: 42155
E
E.M.A.
Medina Eldem Sokak No.41/6
Yüksel Caddesi
ANKARA
Tel: 175 622
M,P

UNITED ARAB EMIRATES

Emilat Ltd.
P.O. Box 1641
SHARJAH
Tel: 354121, 354123
Telex: 68136 Emilat Sh
CH,CS,E,M,P

UNITED KINGDOM

see: GREAT BRITAIN

NORTHERN IRELAND

SCOTLAND



UNITED STATES

Alabama

Hewlett-Packard Co.
700 Century Park South
Suite 128
BIRMINGHAM, AL 35226
Tel: (205) 822-6802
CH,MP

Hewlett-Packard Co.
P.O. Box 4207
8290 Whitesburg Drive, S.E.
HUNTSVILLE, AL 35802
Tel: (205) 881-4591
CH,CM,CS,E,M*

Alaska

Hewlett-Packard Co.
1577 "C" Street Plaza, Suite 252
ANCHORAGE, AK 99501
Tel: (907) 278-5709
CH*

Arizona

Hewlett-Packard Co.
2336 East Magnolia Street
PHOENIX, AZ 85034
Tel: (602) 273-8000
A,CH,CM,CS,E,MS

Hewlett-Packard Co.
2424 East Aragon Road
TUCSON, AZ 85706
Tel: (602) 889-4631
CH,E,MS**

Arkansas

Hewlett-Packard Co.
P.O. Box 5646
Brady Station
LITTLE ROCK, AR 72215
111 N. Filmore
LITTLE ROCK, AR 72205
Tel: (501) 664-8773, 376-1844
MS

California

Hewlett-Packard Co.
99 South Hill Dr.
BRISBANE, CA 94005
Tel: (415) 330-2500
CH,CS

Hewlett-Packard Co.
7621 Canoga Avenue
CANOGA PARK, CA 91304
Tel: (213) 702-8300
A,CH,CS,E,P

Hewlett-Packard Co.
1579 W. Shaw Avenue
FRESNO, CA 93711
Tel: (209) 221-6821
MS

Hewlett-Packard Co.
1430 East Orangethorpe
FULLERTON, CA 92631
Tel: (714) 870-1000
CH,CM,CS,E,MP

Hewlett-Packard Co.
5400 W. Rosecrans Boulevard
LAWDALE, CA 90260
P.O. Box 92105
LOS ANGELES, CA 90009
Tel: (213) 970-7500
CH,CM,CS,MP

Hewlett-Packard Co.
3939 Lankershim Blvd.
NORTH HOLLYWOOD, CA 91604
Tel: (213) 877-1292
Regional Headquarters

Hewlett-Packard Co.
3200 Hillview Avenue
PALO ALTO, CA 94304
Tel: (415) 857-8000
CH,CS,E

Hewlett-Packard Co.
648 W. North Market Boulevard
SACRAMENTO, CA 95834
Tel: (916) 929-7222
A*,CH,CS,E,MS

Hewlett-Packard Co.
9606 Aero Drive
P.O. Box 23333 SAN DIEGO, CA
92123

Tel: (714) 279-3200
CH,CM,CS,E,MP

Hewlett-Packard Co.
P.O. Box 4230

Fullerton, CA 92631

363 Brookhollow Drive
SANTA ANA, CA 92705

Tel: (714) 641-0977
A,CH,CM,CS,MP

Hewlett-Packard Co.
Suite A

5553 Hollister
SANTA BARBARA, CA 93111

Tel: (805) 964-3390

Hewlett-Packard Co.
3003 Scott Boulevard

SANTA CLARA, CA 95050

Tel: (408) 968-7000
A,CH,CM,CS,E,MP

Hewlett-Packard Co.
P.O. Box 4230

Fullerton, CA 92631

363 Brookhollow Drive
SANTA ANA, CA 92705

Tel: (714) 641-0977
A,CH,CM,CS,MP

Hewlett-Packard Co.
Suite A

5553 Hollister
SANTA BARBARA, CA 93111

Tel: (805) 964-3390

Hewlett-Packard Co.
3003 Scott Boulevard

SANTA CLARA, CA 95050

Tel: (408) 968-7000
A,CH,CM,CS,E,MP

Hewlett-Packard Co.
P.O. Box 4230

Fullerton, CA 92631

363 Brookhollow Drive
SANTA ANA, CA 92705

Tel: (714) 641-0977
A,CH,CM,CS,MP

Hewlett-Packard Co.
P.O. Box 4230

Fullerton, CA 92631

363 Brookhollow Drive
SANTA ANA, CA 92705

Tel: (714) 641-0977
A,CH,CM,CS,MP

Hewlett-Packard Co.
P.O. Box 4230

Fullerton, CA 92631

363 Brookhollow Drive
SANTA ANA, CA 92705

Tel: (714) 641-0977
A,CH,CM,CS,MP

Hewlett-Packard Co.
P.O. Box 4230

Fullerton, CA 92631

363 Brookhollow Drive
SANTA ANA, CA 92705

Tel: (714) 641-0977
A,CH,CM,CS,MP

Hewlett-Packard Co.
P.O. Box 4230

Fullerton, CA 92631

363 Brookhollow Drive
SANTA ANA, CA 92705

Tel: (714) 641-0977
A,CH,CM,CS,MP

Hewlett-Packard Co.
P.O. Box 4230

Fullerton, CA 92631

363 Brookhollow Drive
SANTA ANA, CA 92705

Hewlett-Packard Co.
Executive Park Suite 306
AUGUSTA, GA 30907
Tel: (404) 736-0592
MS

Hewlett-Packard Co.
P.O. Box 2103
WARNER ROBINS, GA 31099
1172 N. Davis Drive
WARNER ROBINS, GA 31099
Tel: (912) 923-8831
E

Hawaii

Hewlett-Packard Co.
Kawaiahao Plaza, Suite 190
567 South King Street
HONOLULU, HI 96813
Tel: (808) 526-1555
A,CH,E,MS

Idaho

Hewlett-Packard Co.
250 S. Beechwood
1st Floor, JUB Engineering Bldg.
BOISE, ID 83702
Tel: (208) 376-6000
CH,M*

Illinois

Hewlett-Packard Co.
211 Prospect Road, Suite C
BLOOMINGTON, IL 61701
Tel: (309) 863-0383
CH,MS**

Hewlett-Packard Co.
1100 31st Street
DOWNERS GROVE, IL 60515
Tel: (312) 960-5760
CH,CS

Hewlett-Packard Co.
5201 Tolview Drive
ROLLING MEADOWS, IL 60008
Tel: (312) 255-9800
A,CH,CM,CS,E,MP

Indiana

Hewlett-Packard Co.
P.O. Box 50807
7301 No. Shadeland Avenue
INDIANAPOLIS, IN 46250
Tel: (317) 842-1000
A,CH,CM,CS,E,MS

Iowa

Hewlett-Packard Co.
1776 22nd Street, Suite 1
WEST DES MOINES, IA 50265
Tel: (515) 224-1435
CH,MS**

Hewlett-Packard Co.
2415 Heinz Road
IOWA CITY, IA 52240
Tel: (319) 351-1020, 366-6477
CH,E*,MS

Kansas

Hewlett-Packard Co.
1644 S. Rock Road
WICHITA, KA 67207
Tel: (316) 684-8491
CH

Kentucky

Hewlett-Packard Co.
10170 Linn Station Road
Suite 525
LOUISVILLE, KY 40223
Tel: (502) 426-0100
A,CH,CS,MS

Louisiana

Hewlett-Packard Co.
P.O. Box 1449
KENNER, LA 70062
160 James Drive East
DESTAHH, LA 70047
Tel: (504) 467-4100
A,CH,CS,E,MS

Maryland

Hewlett-Packard Co.
7121 Standard Drive
HANOVER, MD 21076
Tel: (301) 796-7700
A,CH,CM,CS,E,MS

Hewlett-Packard Co.
2 Choke Cherry Road
ROCKVILLE, MD 20850
Tel: (301) 948-6370
Telex: 710-828-9685
A,CH,CM,CS,E,MP

Massachusetts

Hewlett-Packard Co.
32 Hartwell Avenue
LEXINGTON, MA 02173
Tel: (617) 861-8960
A,CH,CM,CS,E,MP

Michigan

Hewlett-Packard Co.
23855 Research Drive
FARMINGTON HILLS, MI 48024
Tel: (313) 476-6400
A,CH,CM,CS,E,MP

Hewlett-Packard Co.
4326 Cascade Road S.E.
GRAND RAPIDS, MI 49506
Tel: (616) 957-1970
CH,CS,MS

Minnesota

Hewlett-Packard Co.
2025 W. Larpenteur Ave.
ST. PAUL, MN 55113
Tel: (612) 644-1100
A,CH,CM,CS,E,MP

Mississippi

Hewlett-Packard Co.
P.O. Box 5028
1675 Lakeland Drive
JACKSON, MS 39216
Tel: (601) 982-9363
MS

Missouri

Hewlett-Packard Co.
11131 Colorado Avenue
KANSAS CITY, MO 64137
Tel: (816) 763-8000
Telex: 910-771-2087
A,CH,CM,CS,E,MS

Hewlett-Packard Co.
1024 Executive Parkway
ST. LOUIS, MO 63141
Tel: (314) 878-0200
A,CH,CS,E,MP

Nebraska

Hewlett-Packard
7101 Mercy Road
Suite 101, IBX Building
OMAHA, NE 68106
Tel: (402) 392-0948
CM,MS

Nevada

Hewlett-Packard Co.
Suite D-130
5030 Paradise Blvd.
LAS VEGAS, NV 89119
Tel: (702) 736-6610
MS**

New Jersey

Hewlett-Packard Co.
Crystal Brook Professional Building
Route 35
EATONTOWN, NJ 07724
Tel: (201) 542-1384
A*,C*,E*,F*

New Jersey

Hewlett-Packard Co.
W120 Century Road
PARAMUS, NJ 07652
Tel: (201) 265-5000
A,CH,CM,CS,E,MP

Hewlett-Packard Co.
60 New England Av. West
PISCATAWAY, NJ 08854
Tel: (201) 981-1199
A,CH,CM,CS,E

New Mexico

Hewlett-Packard Co.
P.O. Box 11634
ALBUQUERQUE, NM 87112
11300 Lomas Blvd., N.E.
ALBUQUERQUE, NM 87123
Tel: (505) 292-1330
Telex: 910-989-1185
CH,CS,E,MS

New York

Hewlett-Packard Co.
5 Computer Drive South
ALBANY, NY 12205
Tel: (518) 458-1550
Telex: 710-444-4691
A,CH,E,MS

Hewlett-Packard Co.
P.O. Box 297
9600 Main Street
CLARENCE, NY 14031
Tel: (716) 759-8621
Telex: 710-523-1893
CH

Hewlett-Packard Co.
200 Cross Keys Office
FAIRPORT, NY 14450
Tel: (716) 223-9950
Telex: 510-253-0092
CH,CM,CS,E,MS

Hewlett-Packard Co.
7641 Henry Clay Blvd.
LIVERPOOL, NY 13088
Tel: (315) 451-1820
A,CH,CM,E,MS

Hewlett-Packard Co.
No. 1 Pennsylvania Plaza
55th Floor
34th Street & 8th Avenue
NEW YORK, NY 10119
Tel: (212) 971-0800
CH,CS,E*,M*

Hewlett-Packard Co.
3 Crossways Park West
WOODBURY, NY 11797
Tel: (516) 921-0300
Telex: 510-221-2183
A,CH,CM,CS,E,MS

North Carolina

Hewlett-Packard Co.
4915 Water's Edge Drive
Suite 160
RALEIGH, NC 27606
Tel: (919) 851-3021
C,M

Hewlett-Packard Co.
P.O. Box 26500
5605 Roanne Way
GREENSBORO, NC 27450
Tel: (919) 852-1800
A,CH,CM,CS,E,MS

Ohio

Hewlett-Packard Co.
9920 Carver Road
CINCINNATI, OH 45242
Tel: (513) 891-9870
CH,CS,MS

Hewlett-Packard Co.
16500 Sprague Road
CLEVELAND, OH 44130
Tel: (216) 243-7300
Telex: 810-423-9430
A,CH,CM,CS,E,MS

Hewlett-Packard Co.
962 Crupper Ave.
COLUMBUS, OH 43229
Tel: (614) 436-1041
CH,CM,CS,E*

Arranged alphabetically by country

Hewlett-Packard Co.
P.O. Box 280
330 Progress Rd.
DAYTON, OH 45449
Tel: (513) 859-8202
A,CH,CM,E*,MS

Oklahoma
Hewlett-Packard Co.
P.O. Box 32008
Oklahoma City, OK 73123
1503 W. Gore Blvd., Suite #2
LAWTON, OK 73505
Tel: (405) 248-4248
C

Hewlett-Packard Co.
P.O. Box 32008
OKLAHOMA CITY, OK 73123
304 N. Meridian Avenue, Suite A
OKLAHOMA CITY, OK 73107
Tel: (405) 946-9499
A*,CH,E*,MS
Hewlett-Packard Co.
Suite 121
9920 E. 42nd Street
TULSA, OK 74145
Tel: (918) 665-3300
A**,CH,CS,M*

Oregon
Hewlett-Packard Co.
1500 Valley River Drive
Suite 330
EUGENE, OR 97401
Tel: (503) 683-8075
C

Hewlett-Packard Co.
9255 S. W. Pioneer Court
WILSONVILLE, OR 97070
Tel: (503) 682-8000
A,CH,CS,E*,MS

Pennsylvania
Hewlett-Packard Co.
1021.8th Avenue
King of Prussia Industrial Park
KING OF PRUSSIA, PA 19406
Tel: (215) 265-7000
Telex: 510-660-2670
A,CH,CM,CS,E,MP

Hewlett-Packard Co.
111 Zela Drive
PITTSBURGH, PA 15238
Tel: (412) 782-0400
A,CH,CS,E,MP

South Carolina
Hewlett-Packard Co.
P.O. Box 21708
Brookside Park, Suite 122
1 Harbison Way
COLUMBIA, SC 29210
Tel: (803) 732-0400
CH,E,MS

Hewlett-Packard Co.
Koger Executive Center
Chesterfield Bldg., Suite 124
GREENVILLE, SC 29615
Tel: (803) 748-5601
C

Tennessee
Hewlett-Packard Co.
P.O. Box 22490
224 Peters Road
Suite 102
KNOXVILLE, TN 37922
Tel: (615) 691-2371
A*,CH,MS

Hewlett-Packard Co.
3070 Directors Row
MEMPHIS, TN 38131
Tel: (901) 346-8370
A,CH,MS

Hewlett-Packard Co.
230 Great Circle Road
Suite 216
NASHVILLE, TN 32228
Tel: (615) 255-1271
MS**

Texas
Hewlett-Packard Co.
Suite 310W
7800 Shoal Creek Blvd.
AUSTIN, TX 78757
Tel: (512) 459-3143
E

Hewlett-Packard Co.
Suite C-110
4171 North Mesa
EL PASO, TX 79902
Tel: (915) 533-3555, 533-4489
CH,E*,MS**

Hewlett-Packard Co.
5020 Mark IV Parkway
FORT WORTH, TX 76106
Tel: (817) 625-6361
CH,CS*

Hewlett-Packard Co.
P.O. Box 42816
HOUSTON, TX 77042
10535 Harwin Street
HOUSTON, TX 77036
Tel: (713) 776-6400
A,CH,CM,CS,E,MP

Hewlett-Packard Co.
3309 67th Street
Suite 24
LUBBOCK, TX 79413
Tel: (806) 799-4472
M

Hewlett-Packard Co.
P.O. Box 1270
RICHARDSON, TX 75080
930 E. Campbell Rd.
RICHARDSON, TX 75081
Tel: (214) 231-6101
A,CH,CM,CS,E,MP

Hewlett-Packard Co.
P.O. Box 32993
SAN ANTONIO, TX 78216
1020 Central Parkway South
SAN ANTONIO, TX 78232
Tel: (512) 494-9336
CH,CS,E,MS

Utah
Hewlett-Packard Co.
P.O. Box 26626
3530 W. 2100 South
SALT LAKE CITY, UT 84119
Tel: (801) 974-1700
A,CH,CS,E,MS

Virginia
Hewlett-Packard Co.
P.O. Box 9669
2914 Hungary Spring Road
RICHMOND, VA 23228
Tel: (804) 285-3431
A,CH,CS,E,MS

Hewlett-Packard Co.
3106 Peters Creek Road, N.W.
ROANOKE, VA 24019
Tel: (703) 563-2205
CH,E**

Hewlett-Packard Co.
5700 Thurston Avenue
Suite 111
VIRGINIA BEACH, VA 23455
Tel: (804) 460-2471
CH,MS

Washington
Hewlett-Packard Co.
15815 S.E. 37th Street
BELLEVUE, WA 98006
Tel: (206) 643-4000
A,CH,CM,CS,E,MP

Hewlett-Packard Co.
Suite A
708 North Argonne Road
SPOKANE, WA 99208
Tel: (509) 922-7000
CH,CS

West Virginia
Hewlett-Packard Co.
4604 MacCorkle Ave., S.E.
CHARLESTON, WV 25304-4297
Tel: (304) 925-0492
A,MS

Wisconsin
Hewlett-Packard Co.
150 S. Sunny Slope Road
BROOKFIELD, WI 53005
Tel: (414) 784-8600
A,CH,CS,E*,MP

URUGUAY
Pablo Ferrando S.A.C. e.i.
Avenida Italia 2877
Casilla de Correo 370
MONTEVIDEO
Tel: 80-2586
Telex: Public Booth 901
A,CM,E,M

Guillermo Kraft del Uruguay S.A.
Av. Lib. Brig. Gra. Lavalleja 2083
MONTEVIDEO
Tel: 234588, 234808, 208830
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Milentija Popovica 9
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Telex: 12042, 12322 YU SAV CEN
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Hewlett-Packard
Koprska 46
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Tel: 321674, 315879
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EASTERN USA
Hewlett-Packard Co.
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WESTERN USA
Hewlett-Packard Co.
3939 Lankersim Road
LOS ANGELES, CA 91604
Tel: (213) 877-1282

OTHER INTERNATIONAL AREAS
Hewlett-Packard Co.
Intercontinental Headquarters
3495 Deer Creek Road
PALO ALTO, CA 94304
Tel: (415) 857-1501
Telex: 034-8300
Cable: HEWPACK

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