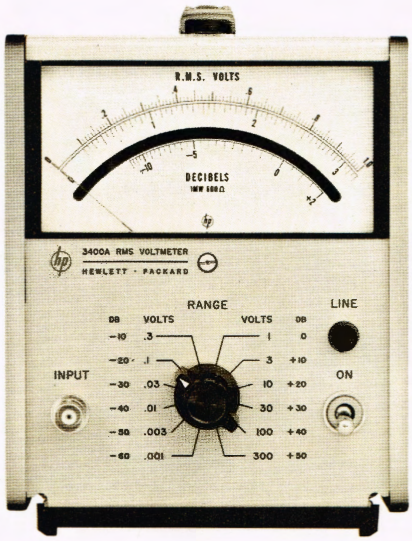
OPERATING AND SERVICE MANUAL

RMS VOLTMETER

3400A



HEWLETT PACKARD

OPERATING AND SERVICE MANUAL

(HP PART NO. 03400-90008)

MODEL 3400A
RMS VOLTMETER

SERIALS PREFIXED: 1140A*

* Appendix C, Manual Backdating Changes, adapts this manual to instruments with serial numbers 0979A13725 and below, and serials prefixed: 322-, 401-, 528-, and 714-.

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

01768-5

Printed: JUNE 1972

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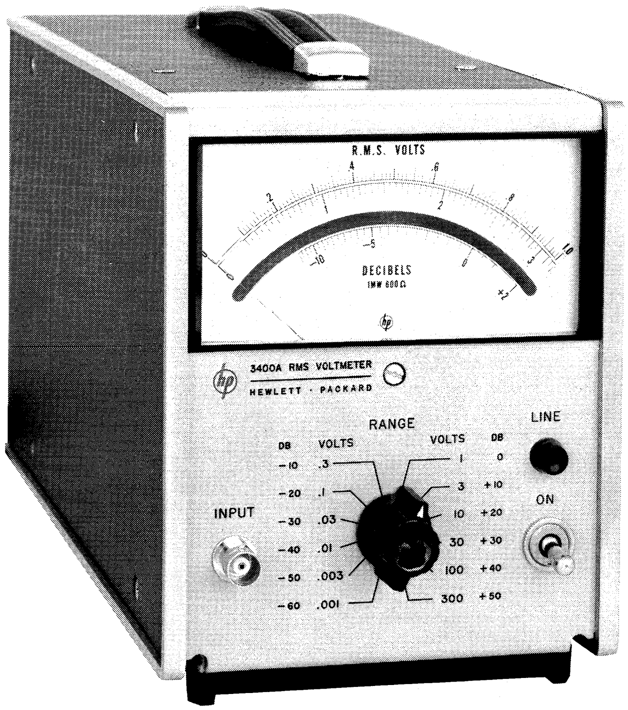


Table 1-1. Model 3400A Specifications

VOLTAGE RANGE: 1 mV to 300 V full scale, 12 ranges.

DB RANGE: -72 to +52 dBm (0 dBm = 1 mW in 600Ω).

FREQUENCY RANGE: 10 Hz to 10 MHz.

RESPONSE: Responds to rms value (heating value) of input signal.

METER ACCURACY: % of Full Scale (20°C to 30°C)*

10 Hz 50 Hz 1 MHz 2 MHz 3 MHz 10 MHz

±5%	±1%	±2%	±3%	±5%

AC-to-DC CONVERTER ACCURACY: % of Full Scale (20°C to 30°C)*

10 Hz 50 Hz 1 MHz 2 MHz 3 MHz 10 MHz

±5%	±0.75%	±2%	±3%	±5%

OUTPUT: Negative 1 V dc into open circuit for full-scale deflection, proportional to meter deflection; 1 mA maximum; nominal source impedance 1000Ω.

OUTPUT NOISE: < 1 mV RMS.

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).

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.

AC OVERLOAD: 30 dB above full scale or 800 V peak, whichever is less, on each range.

MAXIMUM DC INPUT: 600 V on any range.

RESPONSE TIME: For a step function, < 5 seconds to respond to final value.

POWER: 115 or 230 V ±10%, 48 to 440 Hz. approximately 7 watts.

WEIGHT: Net 7 1/4 lbs. (3, 3kg); shipping 10 lbs. (5 kg).

OVERALL DIMENSIONS: 6 1/2" high; 5 1/8" wide; 11 11/16" deep.

*Temperature Coefficient: ±0.1% over range of 0°C to 20°C and 30°C to 55°C.

SCOPE OF MANUAL

This manual contains the information necessary for operating and servicing the standard Model 3400A RMS Voltmeter and the Model 3400A/Option 01 RMS Voltmeter (DB scale uppermost).

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 ±1% from 50 Hz to 1 MHz, ±2% from 1 MHz to 2 MHz, ±3% from 2 MHz to 3 MHz, and ±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 1-2. Equipment Supplied

IDENTIFICATION NUMBER	QUANTITY	DESCRIPTION
10110A	1	Adapter (BNC to dual banana jack)
8120-1348	1	Power Cord
03400-90008	1	Operating and Service Manual

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. (See Appendix B for office locations.)

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 mars and scratches and in perfect electrical condition, it should be inspected for any physical damge 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 (±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. (See Appendix B for office location.)

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.

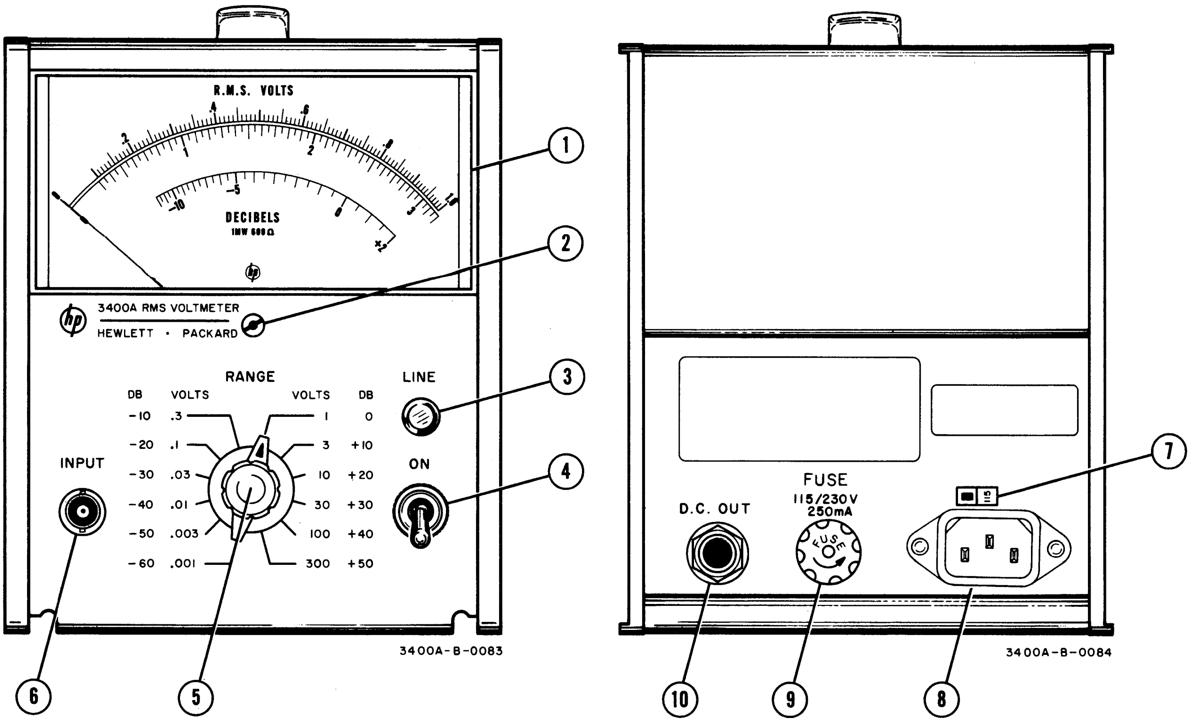
2-17. If original container is not to be used, proceed as follows:

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.



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

Figure 3-1. Model 3400A Controls and Indicators

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 INSTRUCTIONS.

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 a -hp-Model 412A DC Voltmeter to measure the dc component. Substitute the reading from the Model 412A 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 a -hp- Model 3440A Digital Voltmeter for high resolution measurements and/or a Mosely 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.

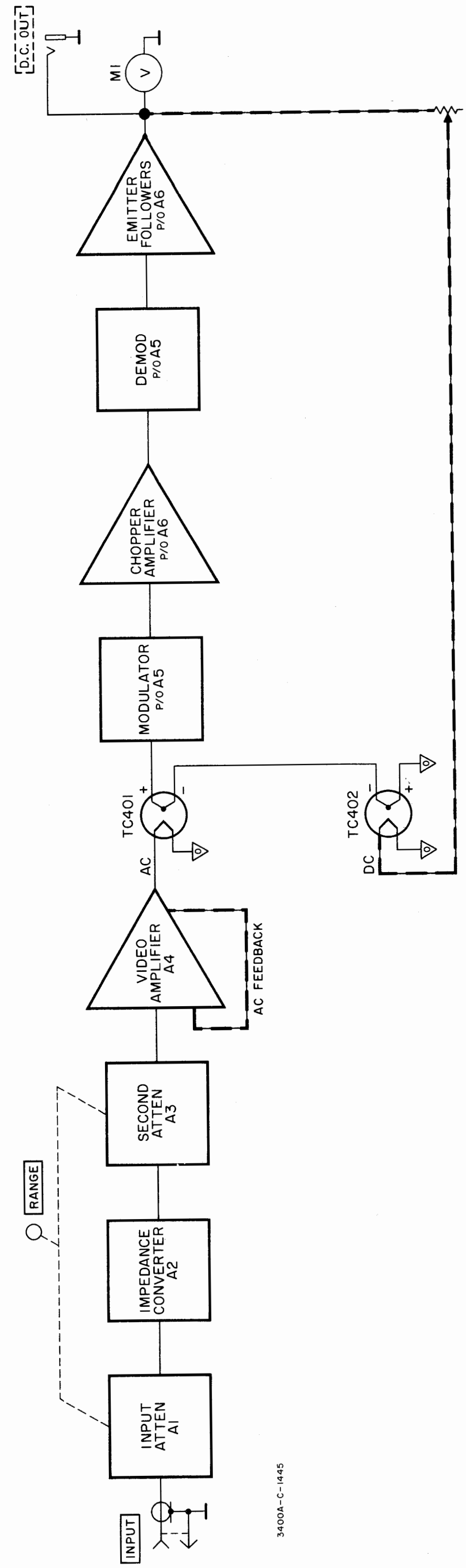


Figure 4-1. Block Diagram

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 Model 3400A comprises two attenuators, an impedance converter, a video amplifier, a photoconductor chopper (modulator/demodulator), a chopper amplifier, an emitter follower, a thermocouple pair, and a direct reading meter. (See Figure 4-1.)

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 modulated by modulator A5. The modulator comprises two photocells which are alternately illuminated by two neon lamps which in turn are controlled by the oscillator located on power supply assembly A7. The output of the modulator is a square wave whose amplitude is proportional to the dc input level.

4-8. The square wave output of the modulator is amplified by chopper amplifier A6. The chopper amplifier is a high gain ac amplifier. Its output is applied to demodulator A5. The demodulator output is a dc level whose magnitude is proportional to the amplitude of the ac input. The demodulator output is applied to two direct coupled emitter followers. The emitter follower is used to make the impedance transformation from the high impedance output of the demodulator to the low impedance of the direct reading meter M1 and TC402; the second thermocouple of the thermocouple pair.

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 emitter followers. The difference in the heating effect of these voltages is felt as a dc input to modulator A5. This difference input is amplified and is fed to TC402 and to meter M1. This amplified dc voltage represents the rms value of the ac signal applied at the INPUT jack. By using two "matched" thermocouples and measuring the difference, the output to the modulator will be linear. Using two thermocouples also provides temperature stability.

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 (10 MHz 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 mid-band 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 break-down diode, establishes the operating potentials for the output amplifier.

4-27. PHOTOCHOPPER ASSEMBLY A5, CHOPPER AMPLIFIER ASSEMBLY A6, AND THERMOCOUPLE PAIR (PART OF A4).

4-28. The modulator/demodulator, chopper amplifier, 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. See modulator/demodulator, chopper amplifier, and thermocouple pair schematic diagram 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 photocell V501.

4-30. Photocells V501 and V502 in conjunction with neon lamps DS501 and DS502 form a modulator circuit. The neon lamps are lighted alternately between 90 and 100 Hz. Each lamp illuminates one of the photocells. DS501 illuminates V501;DS502 illuminates V502. When a photocell is illuminated it has a low resistance compared to its resistance when dark. Therefore, when V501 is illuminated, the output of thermocouple TC401 is applied to the input of the chopper amplifier through V501. When V502 is illuminated, a ground signal is applied to the chopper amplifier. The alternate illumination of V501 and V502 modulates the dc input at a frequency between 90 and 100 Hz. The modulator output is a square wave whose amplitude is proportional to the dc input level.

4-31. The chopper amplifier, consisting of Q601 through Q603, is a high gain amplifier which amplifies the square wave developed by the modulator. Power supply voltage variations are reduced by diodes CR601 thru CR603. The amplified output is taken from the collector of Q603 and applied to the demodulator through emitter follower Q604.

4-32. The demodulator comprises two photocells, V503 and V504, which operate in conjunction with DS501 and DS502; the same neon lamps used to illuminate the photocells in the modulator. Photocells V503 and V504 are illuminated by DS501 and DS502, respectively.

4-33. The demodulation process is the reverse of the modulation process discussed in Paragraph 4-30. The output of the demodulator is a dc level which is proportional to the demodulator input. The magnitude and phase of the input square wave determines the magnitude and polarity of the dc output level. This dc output level is applied to two emitter follower output stages.

4-34. The emitter follower is needed to match the high output impedance of the demodulator to the low input impedance of the meter and thermocouple circuits. The voltage drop across CR604 in the collector circuit of Q605 is the operating bias for Q604. This fixed bias prevents Q605 failure when the base voltage is zero with respect to ground.

4-35. The dc level output, taken from the emitter of Q606, is applied to meter M1 and 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 modulator then becomes the difference in the dc outputs of the two thermocouples. When the difference between the two thermocouples becomes zero the dc from the emitter followers (driving the meter) will be equal to the ac from the video amplifier.

4-36. Noise on the modulated square wave is suppressed by feedback from emitter of Q606 through C607 and C608 to the resistive element of TC402.

4-37. POWER SUPPLY ASSEMBLY A7.

4-38. 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.

4-39. 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.

4-40. REGULATOR OPERATION.

4-41. 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.

4-42. +75 VOLT SUPPLY.

4-43. 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.

4-44. -17.5 VOLT SUPPLY.

4-45. 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 4-41.

4-46. -6.3 VOLT SUPPLY.

4-47. 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.

4-48. NEON LAMP DRIVE OSCILLATOR.

4-49. The neon lamp drive oscillator consists of transistor Q706, diode CR718, resistors R701, R702, R712, R713, and capacitor C711. Transistor Q706 is held on (conducting) by the base bias developed at the junction of R712 and CR718. The collector current of Q706 charges up capacitor C711 through R701 or R702 depending upon the illuminated neon lamp on the Chopper Amplifier Assembly A6. When the capacitor reaches a sufficient charge to fire the dark neon lamp, the illumination of the neon lamps alternate and the capacitor discharges through the previously dark neon lamp. With the previously dark neon lamp illuminated, the capacitor charges up in the opposite direction until firing the previously illuminated neon lamp. The cycle described above repeats at a frequency of 90 to 100 Hz as determined by the RC time constants of R701 and C711, and R702 and C711.

Table 5-1. Required Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
DC Voltmeter	Accuracy: ±0.1% full scale Voltage Range: 10 mV to 100 V	Performance Checks Adjustment and Calibration	-hp- Model 3440A/3443A Digital Voltmeter
Voltmeter Calibrator	Voltage Range: 1 mV to 300 V rms Frequency: 400 Hz	Performance Checks Adjustment and Calibration Troubleshooting	-hp- Model 738B Voltmeter Calibrator
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: 0.005 v/cm Bandwidth: dc to 20 MHz	Adjustment and Calibration Troubleshooting	-hp- Model 140A/1402A/1420A
Pulse Generator	Pulse Width: variable to 10 μsec Pulse Amp: ±10 volts peak, variable Pulse Rate: 250 to 1000 pps	Performance Checks	-hp- Model 214A Pulse Generator
Frequency Counter	Range: 250 to 1000 Hz Accuracy: ±1 count Time Interval: 1 μsec	Performance Checks	-hp- Model 5233L Electronic Counter
Peak Responding Voltmeter	Voltage Range: 0.5 V to 300 V Accuracy: ±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
Current Supply/Ohmmeter	Output: 5 mA of current into 100Ω Ohm Range: 1Ω to 10 MΩ Accuracy: ±5%	Troubleshooting	-hp- Model 412A DC Vacuum Tube Voltmeter
RMS Responding Voltmeter	Range: 1 mV full scale	Performance Checks	-hp- Model 3400A RMS Voltmeter
Resistor	200 kΩ, metal film, 1/4 W 1%	Performance Checks	-hp- Part No. 0757-0782
Resistor	499 kΩ, metal film, 1/4 W 1%	Troubleshooting	-hp- Part No. 0757-0327
Capacitor	1 μF	Troubleshooting	-hp- Part No. 0180-0269
50Ω Feedthru Termination	Resistor: fixed comp 50Ω ±5% 1/4 W	Performance Checks	-hp- Model 11048B 50Ω 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. 5060-6038

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 ±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 setup is illustrated in Figure 5-1. A Voltmeter Calibrator -hp- Model 738B and a DC Voltmeter -hp- Model 3440A/3443A) 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 Voltmeter Calibrator for 0.001 volt, rms 400 Hz output; set the DC Voltmeter to measure 1 volt.

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 dc voltmeter 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 5-2. 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

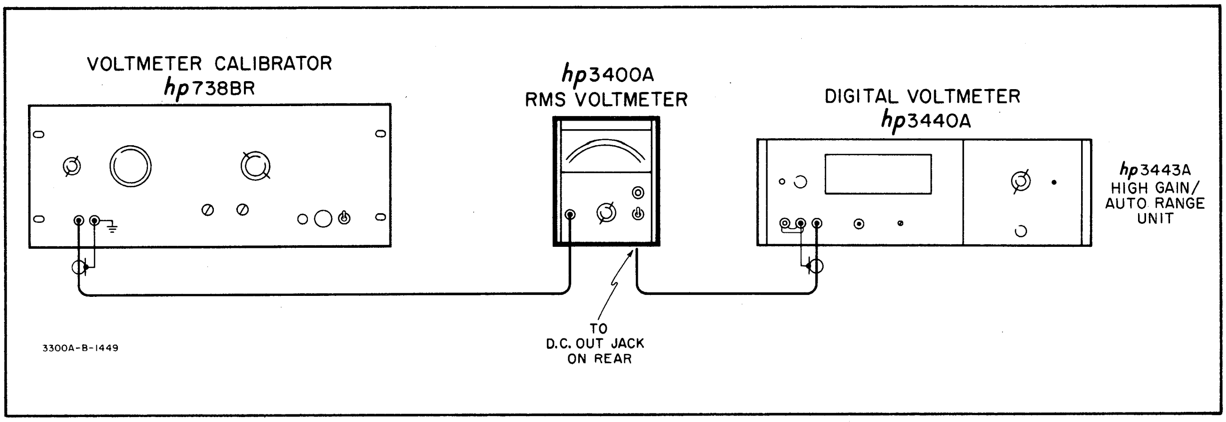


Figure 5-1. Accuracy, Linearity, and DC Output Test Setup

5-9. FREQUENCY RESPONSE CHECK.

NOTE

Connect 50Ω 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.

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.

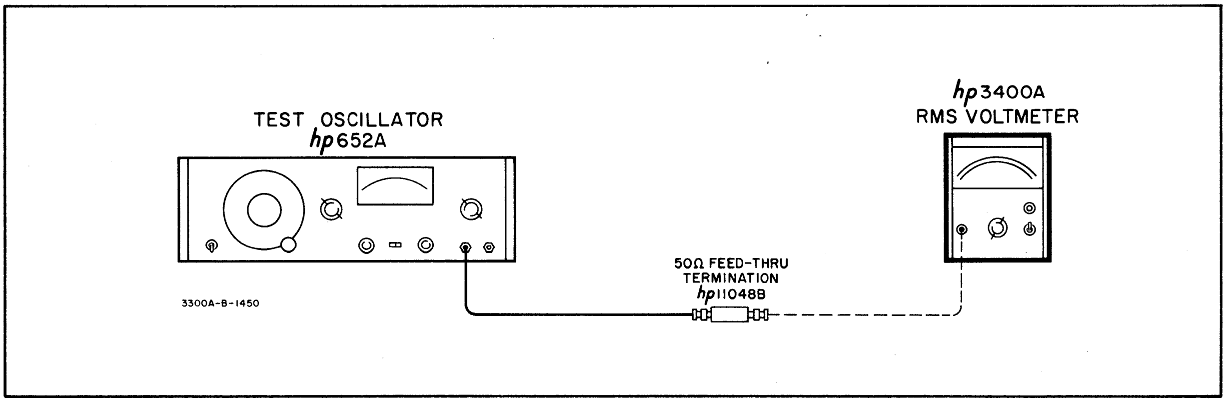


Figure 5-2. Frequency Response Test Setup

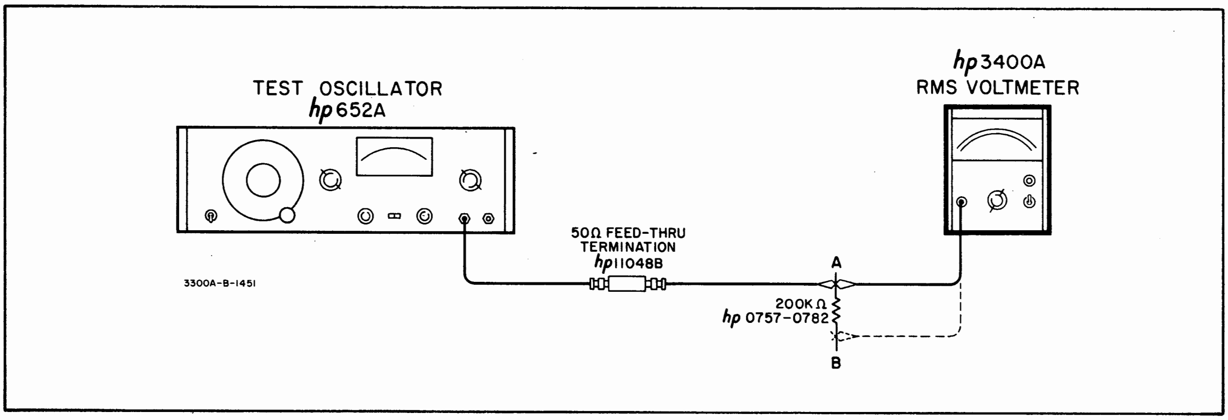


Figure 5-3. Input Impedance Test Setup

d. Connect Model 3400A to position B in Figure 5-3. The 3400A meter reading should change less than 0.02 volts (2 minor divisions). This corresponds to an input impedance of 10 megohms.

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 0.707 volts. 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 0.707 volts. 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 μsec as indicated on electronic counter in time internal mode.

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

NOTE

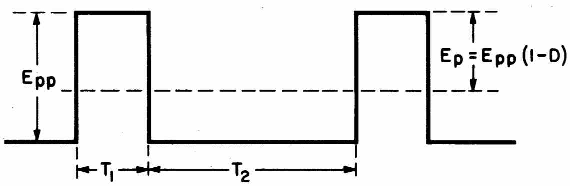
The 410C responds to the positive peak above the average of the input waveform. Since the Model 410C is calibrated to read the rms value of a sine wave a correction factor is required to measure pulse amplitude. The correction factor under these conditions is:

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

see waveform below

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

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



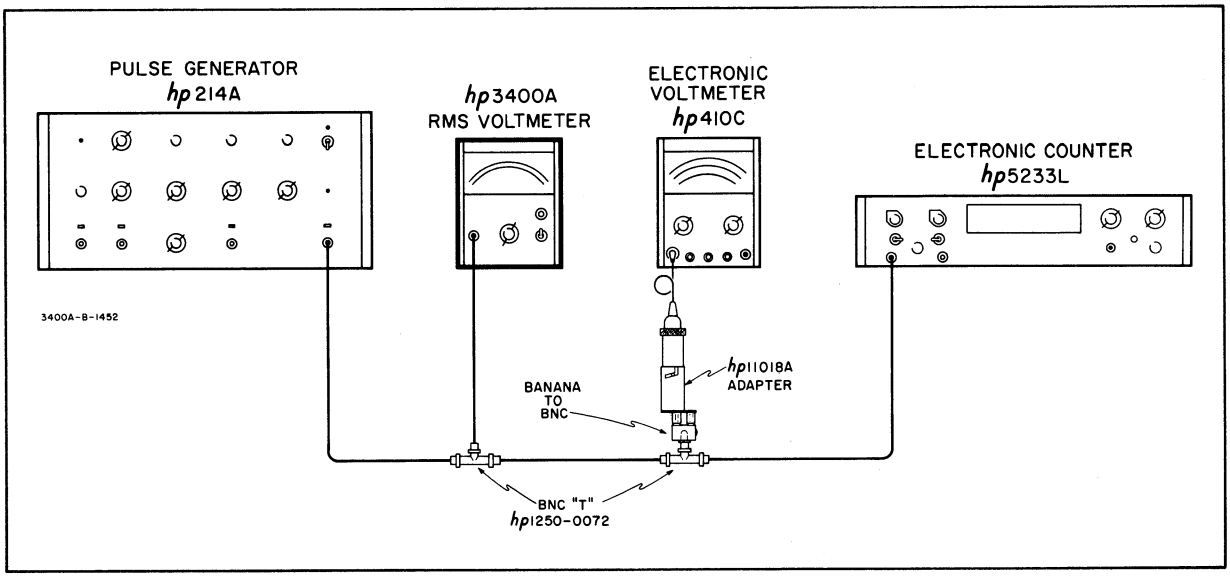
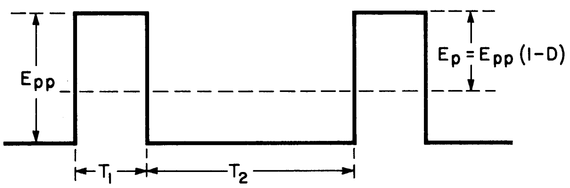


Figure 5-4. Crest Factor Test Setup

This corresponds to a crest factor of 10 where:

$$E_{rms} = E_{pp} \sqrt{D\,(1-D)} \quad \text{where } D = \frac{T1}{T1+T2}$$



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

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

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

d. The Model 3400A should indicate 1 volt, ±4% (includes the ±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, ±4% (includes the ±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 GAIN ADJUSTMENT.

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

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

c. Adjust Voltmeter Calibrator for 0.01 volt rms, 400 Hz output; set DC Voltmeter to read 1.0.

d. Remove Model 3400A top cover; adjust R4 (CAL) for 1.0 volt as indicated on DC Voltmeter. If R4 (CAL) does not have enough range to calibrate the dc output, the value of R3 should be changed. The range of R3 is from 820 ohms to 2.16 k ohms.

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

5-23. 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 1/10 SCALE ADJUST should be set slightly low (needle's width) to reduce meter (needle) offset with shorted input.

c. Adjust R7 (1/10 SCALE ADJUST) for Model 3400A 1/10 scale meter indication. Change value of R8 if it is necessary to increase the adjustment range of R7. The range of R8 is from approximately 270 ohms to 430 ohms. See Table 5-7.

5-24. 1 VOLT ADJUSTMENT.

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

b. Set Model 3400A RANGE switch to 1 volt position.

c. Adjust voltmeter calibrator for 1.0 volt rms, 400 Hz output.

d. Remove right side cover (INPUT side) and adjust R104 (1 V ADJUST) for Model 3400A full-scale meter indication.

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 DC Voltmeter, AC Voltmeter, or 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 μV rms or 1.1 mV p-p
+75 Vdc	Connect DC Voltmeter, AC Voltmeter, or 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 μV rms or 1.1 mV p-p
-6.3 Vdc	Connect DC Voltmeter, AC Voltmeter, or 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 μV rms or 2.0 mV p-p

5-25. HIGH FREQUENCY CALIBRATION.

5-26. 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.

5-27. 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 (1 V, 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 ±1% to 1 MHz, ±2% from 1 MHz to 2 MHz, ±3% from 2 MHz to 3 MHz, or ±5% from 3 MHz to 10 MHz, readjust C102 until optimum response is obtained.

5-28. 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.

5-29. TROUBLESHOOTING PROCEDURES.

5-30. 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.

5-31. 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.

5-32. Table 5-5 contains a summary of known problems by front panel symptoms.

5-33. 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).

5-34. CHECKING THERMOCOUPLES TC401 AND TC402.

5-35. 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.

5-36. To perform these checks, supply 5 mA of current to the heaters of the thermocouples. The -hp- Model 412A DC Vacuum Tube Voltmeter in ohms function on X100 range is ideal for this application. Instruments required for these checks are as follows:

One -hp- Model 412A DC Vacuum Tube Voltmeter.

One DC Voltmeter with 10 mV F. S. capability such as another -hp- 412A or 3440A/3443A Digital Voltmeter.

If the thermocouples fail any of the following checks replace the thermocouples according to procedures outlined in Paragraph 5-37.

a. Turn the instrument off and remove the A6 board.

NOTE

See Figure 6-3 for component locations.

b. Connect test leads of 412A, in ohms function on X100 range, between ground and junction of C413 and C415 on A4 board (this step checks the resistance of heater in TC401). 412A should indicate between 76. 5 to 103. 5 ohms. If not within limits, replace the matched set of thermocouples (-hp- Part No. 0853-0003).

c. Leave the 412A connected as in Step b (412A is used to supply 5 mA of current to heater of TC401 in this step). Connect a DC Voltmeter as follows:

Negative lead to pin 11 on A6 socket.
Positive lead to pin 13 on A6 socket.

Voltmeter should indicate between +6. 5 mV and +9 mV. Note the indication for future reference. If within the test limits, leave DC Voltmeter connected and proceed to step d page 5-14.

Table 5-5. Front Panel Symptoms

SYMPTOMS	POSSIBLE CAUSE
1/2 scale readings on all RANGE switch settings and input voltages.	Chopper Amplifier (A6), Check C612.
3 to 5% meter offset on all ranges with shorted input.	R7 (1/10 SCALE ADJ) misadjusted. C405 (10 MHz ADJ) misadjusted.
400 Hz calibration low and frequency response falls off above 50 kHz.	Q401 or Q402 shorted.
Switching transients exceed 5% of full scale with shorted input.	Check collector voltage of Q201 (should not exceed 9. 0 V).
Instrument has been overloaded.	Check Q201, Q401, Q402 and TC401. See Paragraph 5-34 for details on TC401.
Meter jitter exceeds 0. 5% of full scale.	Check Q601, Photochopper Assembly (neons) see Figure 5-9. Verify the value of R606 to be 3. 3 kΩ (-hp- Part No. 0683-3325).
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.

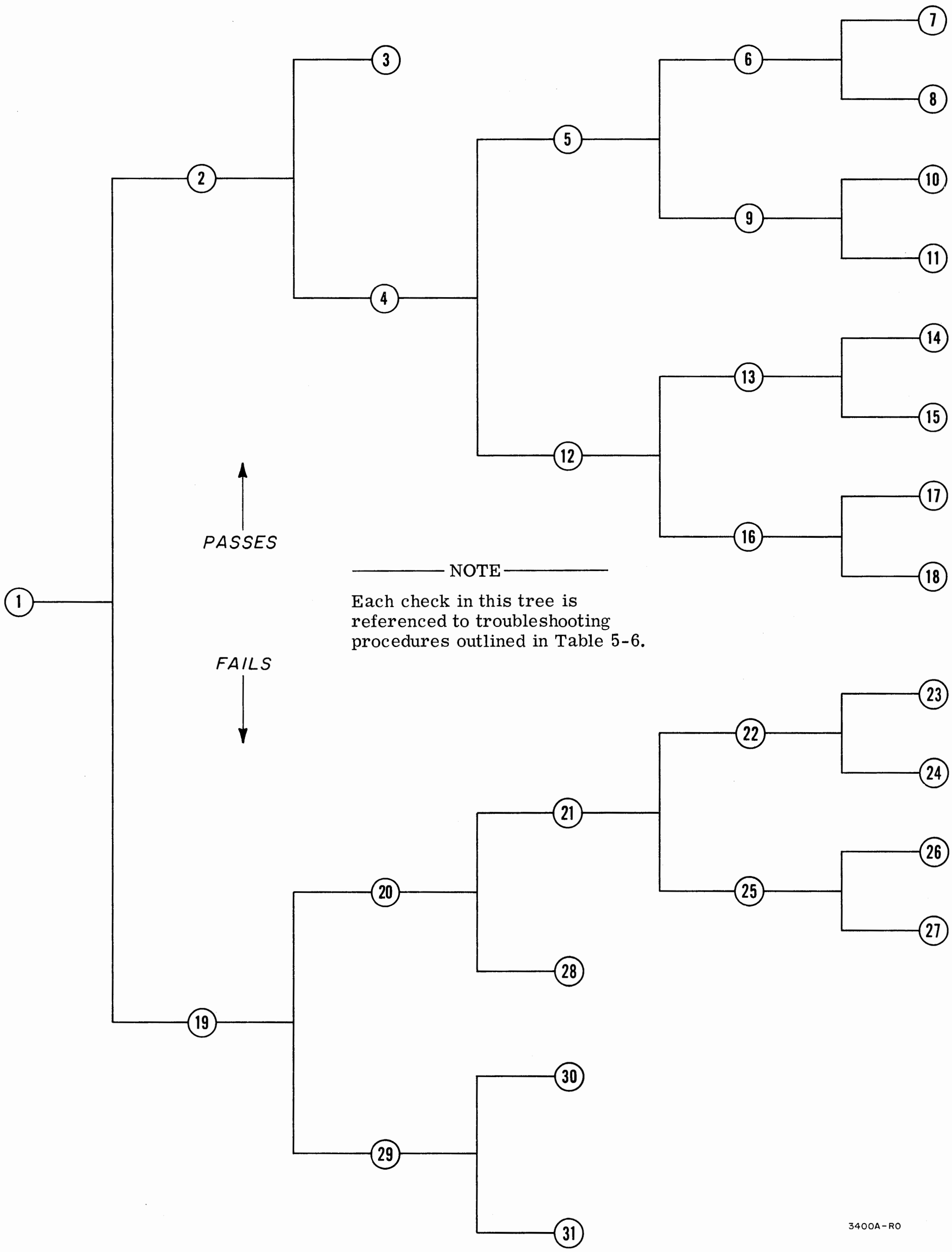
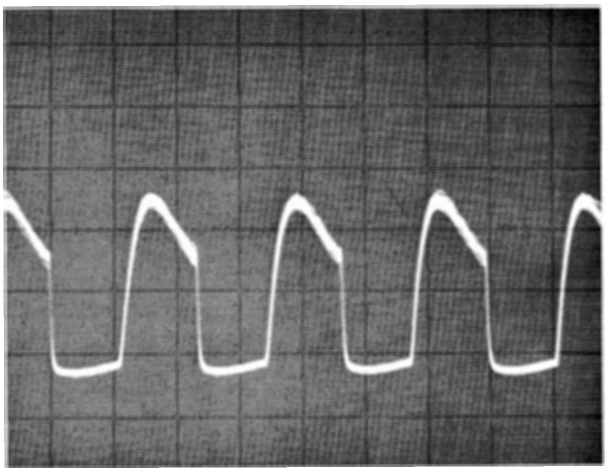


Figure 5-5. Troubleshooting Tree

Table 5-6. Troubleshooting Procedure

CHECK	PROCEDURE	ACTION
①	Apply a 1 volt 400 Hz signal and set the 3400A to the 1 volt range. Measure ac signal at junction of C413 and C415. The reading should be between 240 mV and 280 mV RMS. NOTE Do not use an extender board for measurements on Chopper Amplifier board A6.	PASSES: Proceed to ② FAILS: Proceed to ⑲ (Trouble proceeding the Chopper Amplifier)
②	Measure ac signal at junction of C605 and Demodulator V503 and V504. Refer to Figure 5-6 for waveform.	PASSES: Proceed to ③ FAILS: Proceed to ④ (Trouble in the Chopper Amplifier).



POSITIVE SIDE OF C605

Full Scale deflection

Sweep = 5 ms/cm

Vertical = 0.5 V/cm

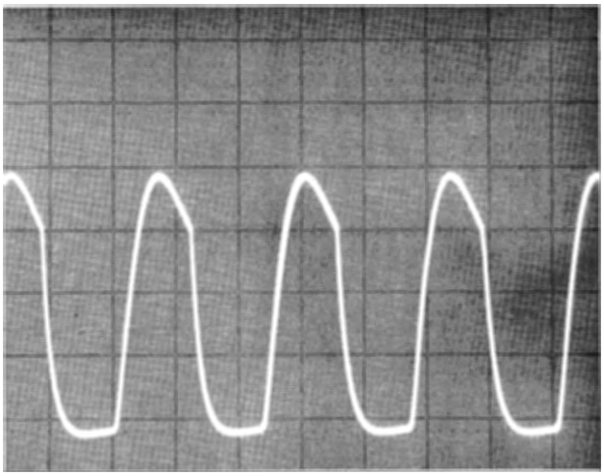
DC coupled

use 10:1 probe

Figure 5-6. Input to Demodulator

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
③	Investigate meter (M1), R5, and R6 for opens.	
④	Remove the input to 3400A. Unsolder red lead from pin 13 (A6) and insert a +10 mV dc signal from 738BR through a 499 kΩ resistor (-hp- Part No. 0757-0327) to pin 13. Measure ac signal at positive side of C605. Refer to Figure 5-7 for waveform.	PASSES: Proceed to ⑤ FAILS: Proceed to ⑫

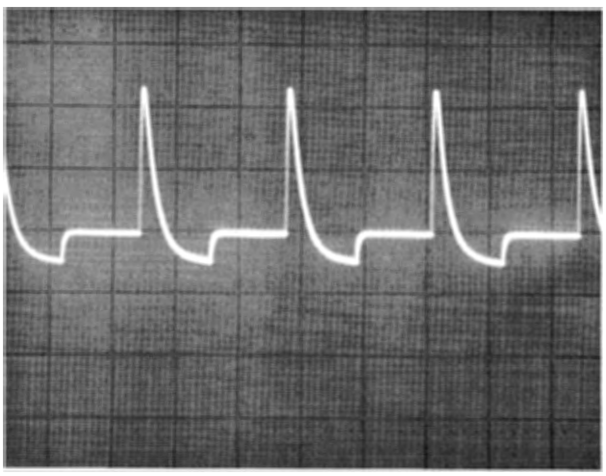


POSITIVE SIDE OF C605
Insert +10 mV signal through 499 kΩ resistor to pin 13 on A6
Sweep = 5 ms/cm
Vertical = 2.0 V/cm
DC coupled
use 10:1 probe

Figure 5-7. Input to Demodulator (feedback loop open)

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
⑤	Measure the dc signal at emitter of Q605. Reading should be approximately -2.35 Vdc.	PASSES: Proceed to ⑥ FAILS: Proceed to ⑨
⑥	Measure the dc signal at pin 9 (A6). Reading should be approximately -1.65 Vdc.	PASSES: Proceed to ⑦ FAILS: Proceed to ⑧
⑦	Investigate R619, R4, and thermocouples. See Paragraph 5-34 for thermocouple check.	
⑧	Investigate Q606 and associated circuit.	
⑨	Measure the ac signal at base of Q605. Refer to Figure 5-8 for waveform.	PASSES: Proceed to ⑩ FAILS: Proceed to ⑪

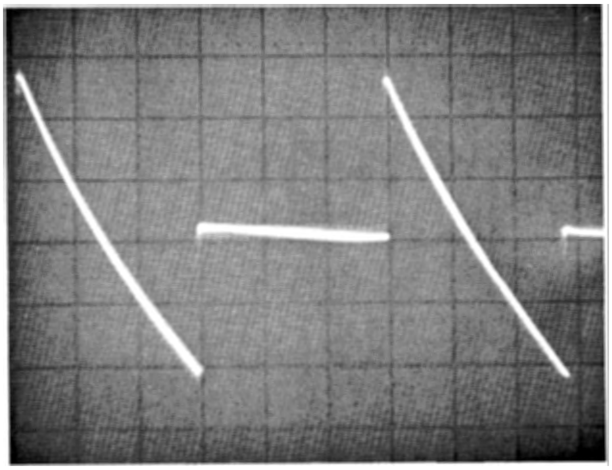


BASE OF Q605
Insert +10 mV signal through 499 kΩ resistor to pin 13 on A6
Sweep = 5 ms/cm
Vertical = 0.2 V/cm
AC coupled
use 10:1 probe

Figure 5-8. Output of Demodulator (feedback loop open)

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
(10)	Investigate Q605, CR604, and R615.	
(11)	Investigate demodulator V503 and V504. See Paragraph 5-39 for photochopper check. Check chopper neon voltage. Refer to Figure 5-9 for waveform. Current variation through neons may cause meter jitter. For proper chopper action, neon firing potential (most negative point on waveform) is normally between 50V and 60V. If the waveform displays noise (nonlinearity) at both extremities, jitter will occur on the meter. If the waveform displays a noise replace the neon subassembly as outlined in Paragraph 5-41.	

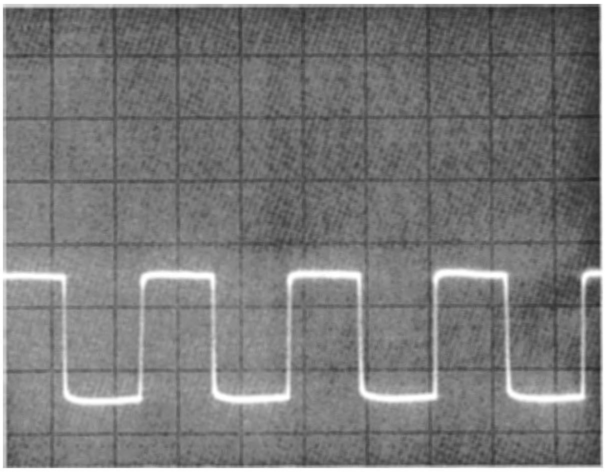


PIN 3 OR 5 ON A6
Sweep = 2 ms/cm
Vertical = 20 V/cm
DC coupled
use 10:1 probe

Figure 5-9. Neon Drive Voltage

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
(12)	Measure the ac signal at collector of Q602. Refer to Figure 5-10 for waveform.	PASSES: Proceed to (13) FAILS: Proceed to (16)

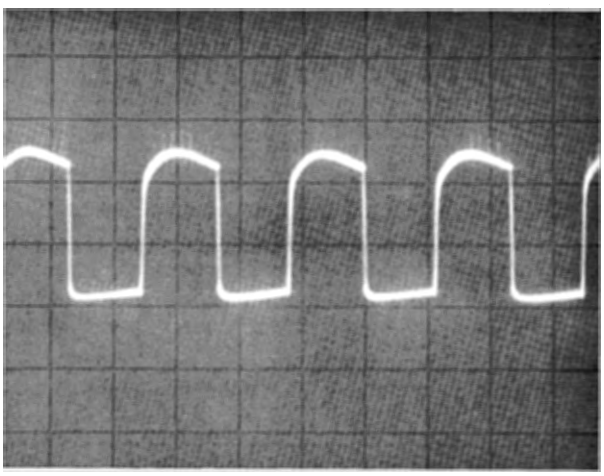


COLLECTOR OF Q602
Insert + 10 mV signal through
499 kΩ resistor to pin 13 on A6
Sweep = 5 ms/cm
Vertical = 0.5 V/cm
DC coupled
use 10:1 probe

Figure 5-10. Collector of Q602 (feedback loop open)

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
13	Measure the ac signal at base of Q604. Refer to Figure 5-11 for waveform.	PASSES: Proceed to (14) FAILS: Proceed to (15)

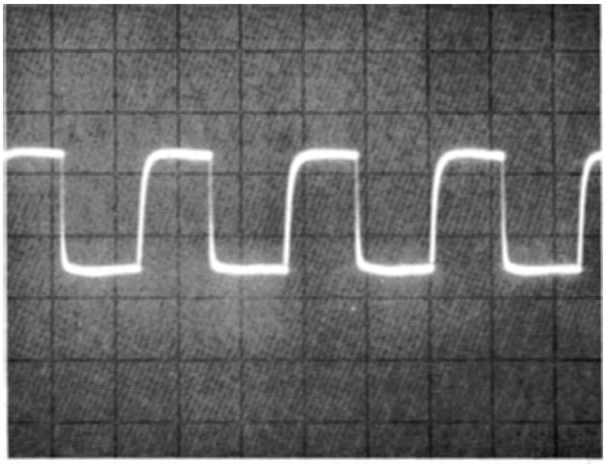


BASE OF Q604
Insert + 10 mV signal through
499 kΩ resistor to pin 13 on A6
Sweep = 5 ms/cm
Vertical = 5 V/cm
AC coupled
no probe required

Figure 5-11. Base of Q604 (feedback loop open)

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
(14)	Investigate Q604, C605, (and demodulator), V503 and V504. See Paragraph 5-39 for photochopper check. Check chopper neon voltage. Refer to Figure 5-9 for waveform. See check number (11) for details.	
(15)	Investigate Q603 and associated circuit.	
(16)	Increase the level of the inserted signal to +0.2 Vdc. Measure the ac signal at the base of Q601. Refer to Figure 5-12 for waveform.	PASSES: Proceed to (17) FAILS: Proceed to (18)



BASE OF Q601

+.2V signal through 499 kΩ resistor to pin 13 on A6

Sweep = 5 ms/cm

Vertical = 5 mV/cm

AC coupled

no probe required

Figure 5-12. Base of Q601 (feedback loop open)

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
(17)	Investigate Q601 and associated circuit.	
(18)	Investigate V501, V502, C601, C602 and R601. See Paragraph 5-39 for photochopper check. Check chopper neon voltage. Refer to Figure 5-9 for waveform. See check number (11) for details.	
(19)	Measure the ac signal at the output of impedance converter A2 (negative side of C205). The reading should be approximately 0.96 mV rms.	PASSES: Proceed to (20) FAILS: Proceed to (23)
(20)	Measure the ac signal at the input to video amplifier A4 positive side of C402. The reading should be approximately 0.96 mV rms.	PASSES: Proceed to (21) FAILS: Proceed to (28)
(21)	Measure the ac signal at the base of Q404. The reading should be approximately 155 mV rms.	PASSES: Proceed to (22) FAILS: Proceed to (25)

Table 5-6. Troubleshooting Procedure (Cont'd)

CHECK	PROCEDURE	ACTION
(22)	Measure the ac signal at the negative side of C427. The reading should be approximately 32 mV rms.	PASSES: Proceed to (23) FAILS: Proceed to (24)
(23)	Investigate C413 and C415.	
(24)	Investigate Q404, Q405, and Q406 circuit. Also check thermocouples. See Paragraph 5-34 for thermocouple check.	
(25)	Measure the ac signal at emitter of Q402. Reading should be 1.85 mV rms.	PASSES: Proceed to (26) FAILS: Proceed to (27)
(26)	Investigate Q401 and Q402 circuit.	
(27)	Investigate Q403 circuit.	
(28)	Investigate second attenuator circuit A3.	
(29)	Measure the ac signal at the input to the impedance converter pin 7 on A2 board. The reading should be approximately 1 mV rms.	PASSES: Proceed to (30) FAILS: Proceed to (31)
(30)	Investigate the impedance converter or power supply. See Table 5-4 for specifications on power supply.	
(31)	Investigate the input attenuator A1.	

d. Remove leads of 412A, connected in step b, and connect 412A between sliver-colored lead on R4 (CAL pot on chassis) and pin 14 on A6 socket (this step checks the resistance of heater in TC402. 412A should indicate between 76.5 to 103.5 ohms.

e. Leave 412A connected as in step d (412A is used to supply 5 mA of current to heater of TC402 in this step). Note indication on DC Voltmeter connected between pins 11 and 13 on A6 socket. Indication should be negative with respect to reading in step c and within 1 mV of that reading.

f. Remove the DC Voltmeter and 412A from 3400A. Connect the 412A between pins 11 and 14 on A6 socket (this steps checks for thermocouples shorted to ground through cover. Indication of 412A should be greater than 200 kΩ. If less than 200 kΩ, look for short to ground.

5-37. THERMOCOUPLE REPLACEMENT.

CAUTION

EXERCISE EXTREME CARE WHEN REMOVING OR REPLACING THE AMPLIFIER PRINTED CIRCUIT BOARD ASSEMBLY AND WHEN SHAPING THE THERMOCOUPLE LEADS.

5-38. 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.

5-39. CHECKING PHOTOCHOPPER ASSEMBLY A5.

NOTE

The following procedure should also be performed after replacing a neon subassembly to verify proper position of neons.

5-40. The following procedure verifies proper operation of the Photochopper Assembly. If the Photochopper fails any of the tests below replace the entire Photochopper Assembly (-hp- Part No. 1990-0223) or the neon subassembly (-hp- Part No. 1990-0224) according to procedures outlined in Paragraph 5-41. See Figure 5-9 to check operation of the neons. To check the photochopper assembly proceed as follows:

a. Remove the Chopper Amplifier board A6.

b. Lift the following component leads from the A6 board.

Negative side of C601
Positive side of C605
Negative side of C606
Base of Q605

c. Place the A6 board on a programmable extender board (-hp- Part No. 5060-6038). Remove pin 13 lead on extender board closest to the A6 board.

d. Place a 1 μF capacitor (-hp- Part No. 0180-0269) across the input leads of an ohmmeter (note the polarity of capacitor and ohmmeter leads).

e. Connect the ohmmeter between pin 13 and ground.

f. Turn on the 3400A. The ohmmeter should indicate > 10 kΩ (this checks the dynamic series resistance of the modulator).

g. Turn off the 3400A, and disconnect ohmmeter.

h. Ground pin 13 on A6 board. Connect ohmmeter between ground and junction of V501 and V502.

i. Turn on the 3400A. The ohmmeter should indicate < 7 kΩ (this checks the dynamic parallel resistance of modulator).

j. Turn off the 3400A. Disconnect all connections made in step h.

k. Connect ohmmeter between ground and V503 lead going to base of Q605.

l. Turn on the 3400A. The ohmmeter should indicate > 10 kΩ (this checks the dynamic series resistance of demodulator).

m. Turn off the 3400A. Disconnect ohmmeter.

n. Ground V503 lead going to base of Q605 and connect ohmmeter between ground and the junction of V503 and V504.

o. Turn on the 3400A. The ohmmeter should indicate < 10 kΩ (this checks the dynamic parallel resistance of demodulator).

p. Turn off the 3400A. Disconnect ohmmeter and reconnect all component leads disconnected in step b.

q. Replace chopper amplifier board.

5-41. REPLACEMENT OF NEON SUBASSEMBLY -hp- PART NO. 1990-0224.

5-42. To replace neon subassembly, proceed as follows:

a. Remove chopper amplifier assembly (A6).

b. Disconnect the photochopper cable at pins 2, 3, 4, and 5 on PC board.

c. Remove two phillips head screws on top cover of the photochopper block.

NOTE

Note the orientation of neon subassembly. The neon subassembly does not lie flat but at an angle within the photochopper block.

d. Remove the neon subassembly.

NOTE

Clean the neon lamps with a tissue to remove finger prints before inserting new neon subassembly in photochopper block.

e. With a new neon subassembly, feed the cable through the hole in the PC board. Place the new neon subassembly into photochopper block in the same orientation as the old neon subassembly.

f. Replace the top cover and two phillips head screws in photochopper block.

g. Reconnect the cable to pins 2, 3, 4 and 5. The larger black lead in the cable connects to pin 2. Other leads identifications are as follows:

White lead to pin 3
Green and red lead to pin 4
Thin black lead to pin 5.

h. Replace chopper amplifier board.

5-43. SERVICING ETCHED CIRCUIT BOARDS.

5-44. 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.

5-45. The etched circuit boards are a 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.

b. Circuit components can be removed by placing 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.

CAUTION

WATER, COMMERCIAL CLEANERS, OR DETERGENTS WILL CAUSE PERMANENT DAMAGE TO PHOTOCHOPPER ASSEMBLY A5.

f. To avoid surface contamination of the printed circuit, clean with weak solution of warm water and mild detergent after repair. Rinse thoroughly with clean water. When completely dry, spray lightly with Krylon (#1302 or equivalent).

Table 5-7. Factory Selected Components

DESIGNATOR	FUNCTION	VALUE		
		LOW	NORMAL	HIGH
C205	Adjust low frequency (10 Hz) response.	---	100 μF (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 μF (selected)	---
R3	Adjust the range of R4 (CAL).	820 Ω	1200 Ω	2.16 kΩ
R8	Adjust the range of R7 (1/10 SCALE ADJ).	---	390 Ω (selected)	---
R419	Adjust voltage at collector of Q406 (no signal input, 1.5 to 2.5 Vdc).	270	300	---

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	0.89	______	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

DESCRIPTION	Frequency	Meter Reading		
FREQUENCY RESPONSE CHECK:				
	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

DESCRIPTION	CHECK
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).

   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.