



OPERATING AND SERVICE MANUAL

(HP PART NO. 00467-90003)

MODEL 467A  
POWER AMPLIFIER/SUPPLY

SERIALS PREFIXED: 444-

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## SECTION I

### GENERAL INFORMATION

#### 1-1. DESCRIPTION.

1-2. The solid state 467A Power Amplifier/Supply is a 10 watt peak power amplifier and -20 to +20 volt dc power supply. The power amplifier has a wide bandwidth with low dc drift from dc to 1 MHz offering wide applications wherever a power source is required. Low distortion (<0.01%), low drift and 0.3% gain accuracy are obtained with high quality components and multiple feedback techniques. The gain of the amplifier may be varied between one and ten by a front panel switch which provides fixed gain steps accurate to  $\pm 0.3\%$ . A variable gain control enables the user to set the gain anywhere between zero and ten with a resolution of better than 0.1% of full output. Table 1-1 gives the specifications for the 467A Power Amplifier/Supply.

#### 1-3. OUTPUT CAPABILITY.

1-4. An output greater than 20 volts peak and 0.5 ampere peak is available from dc up to 1 MHz. The amplifier is protected at all times from short circuits. The input circuit of the 467A is protected against damage from voltages up to 200 volts p-p.

Input and output connectors are provided at the front and rear of the instrument. The amplifier is a three terminal device isolated from chassis and may be floated up to 200 volts dc above chassis ground.

#### 1-5. POWER SUPPLY.

1-6. A front panel switch converts the amplifier to a power supply that delivers  $\pm 20$  volts dc at currents up to  $\pm 0.5$  ampere. The output level is controlled by a potentiometer which permits voltages to be set with resolution of 0.1% of full scale. Full scale ranges of  $\pm 1$ ,  $\pm 2$ ,  $\pm 4$ ,  $\pm 10$ , and  $\pm 20$  volts are selected by the front panel range switch.

#### 1-7. INSTRUMENT IDENTIFICATION.

1-8. Hewlett-Packard uses a two-section eight-digit serial number (000-00000). If the first three digits of the serial number on your instrument do not agree with those on the title page of this manual, change sheets supplied with the manual will define differences between your instrument and the Model 467A described in this manual.

## SECTION II INSTALLATION

### 2-1. INSPECTION.

2-2. Upon receipt, unpack and inspect the instrument for mechanical and electrical damage. Mechanical inspection includes visually checking the instrument for scratched and warped surfaces, damaged control knobs, switches, and indicators, and signs of weather exposure. The electrical inspection involves checking instrument operation against specification values given in Table 1-1. Refer to Paragraph 5-5.

————— NOTE —————

In case of mechanical damage, file a claim with the carrier immediately. If an electrical malfunction occurs, refer to the warranty page in the front of this manual.

### 2-3. INSTALLATION.

2-4. The Model 467A is a submodular unit that can be mounted on a bench, or in a rack or cabinet. It is shipped with plastic feet and tilt stand in place, ready for bench use. When used as a single submodule, it is utilized as a bench unit only. When used in combination with other submodule units, a rack adapter frame or combining case is available for rack or cabinet mounting. The instrument should be installed where ambient temperature does not exceed 50°C (122°F).

### 2-5. POWER REQUIREMENTS.

2-6. The Model 467A can be operated from a 115 or 230 ac volt  $\pm 10\%$  source at 50 to 400 Hz. Power connections are made by plugging the power cable (supplied with the instrument) into the AC POWER male connector at the rear of the unit and the appropriate power receptacle. An 0.8 ampere slow-blow fuse is used for 115 and 230 volt operation.



BEFORE PLUGGING POWER CABLE INTO THE RECEPTACLE, DETERMINE THAT THE LINE VOLTAGE SWITCH ON THE REAR PANEL IS SET PROPERLY TO ACCEPT THAT VOLTAGE (115 OR 230).

### 2-7. THREE-CONDUCTOR POWER CABLE.

2-8. All Hewlett-Packard instruments are equipped with a three-conductor power cable, which complies with the recommendations of the National Electrical

Manufacturer's Association (NEMA) for rack and cabinet grounding. The offset pin on the cable is the ground connector.

————— NOTE —————

When operating from a two-contact outlet, the grounding feature can be maintained by using a three-pronged adapter and connecting the green pigtail on the adapter to ground.

### 2-9. REPACKAGING FOR SHIPMENT.

2-10. The following paragraphs contain a general guide for repackaging of the instrument for shipment. Refer to Paragraph 2-11 if the original container is to be used; 2-12 if it is not. If you have any questions, contact your local -hp- Sales and Service Office. (See Appendix B for office locations.)

————— NOTE —————

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

2-11. 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 container is well sealed with strong tape or metal bands.

2-12. 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. Place 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. GENERAL.

3-2. The Model 467A Power Amplifier/Supply can be operated as a power amplifier or a power supply. Controls on the front panel provide: (1) selection of either operating mode and (2) selection of fixed or variable amplifier gain and power supply ranges.

#### 3-3. DESCRIPTION OF CONTROLS.

3-4. Figure 3-1 gives the description and function of the 467A controls, indicators and connectors.

#### 3-5. OPERATING INSTRUCTIONS.

3-6. When operated as a power amplifier (non-inverting), the Model 467A has four calibrated gain factors (AMPLIFIER: X1, X2, X5, and X10) and provides a maximum output power of 10 watts peak for input frequencies between dc and 1 MHz. Accuracy of  $\pm 0.3\%$  from dc to 10 kHz is obtained when operating into a load of 40 ohms or greater. As a power supply (regulated), the instrument can be operated in five ranges of plus or minus output voltages (SUPPLY:  $\pm 1$ ,  $\pm 2$ ,  $\pm 4$ ,  $\pm 10$ , and  $\pm 20$ ). The amplifier gain, or the  $\pm$  dc output can be varied with the VAR. GAIN/VOLTS ADJ. control. The input and output terminals are dc isolated from earth ground. Connection of a grounding strap between the power line ground ( $\perp$ ) and ( $\text{A}$ ) terminals references both the INPUT and OUTPUT ( $\text{A}$ ) terminals to earth ground.

#### 3-7. AMPLIFIER OPERATING INSTRUCTIONS.

- a. Set the AMPLIFIER/SUPPLY control to the AMPLIFIER position, selecting the desired gain setting (VAR., X1, X2, X5, or X10).
- b. Set the LINE switch to ON.

————— NOTE —————

To assure maximum stability, allow the instrument to warm up for 30 minutes.

- c. Connect DC Voltmeter (-hp- Model 412A) to the 467A OUTPUT terminals; adjust the ZERO control to obtain a zero dc output.
- d. Connect the 467A OUTPUT terminals to the device to which the amplified signal is being applied.
- e. Connect the signal to be amplified to the 467A INPUT terminals.

#### 3-8. POWER SUPPLY OPERATING INSTRUCTIONS.

- a. Connect the 467A OUTPUT terminals to the device to which the power supply is being applied.
- b. Set 467A AMPLIFIER/SUPPLY control in the SUPPLY range to the desired voltage setting ( $\pm 1$ ,  $\pm 2$ ,  $\pm 4$ ,  $\pm 10$ , or  $\pm 20$ ).
- c. Set the LINE switch to ON.

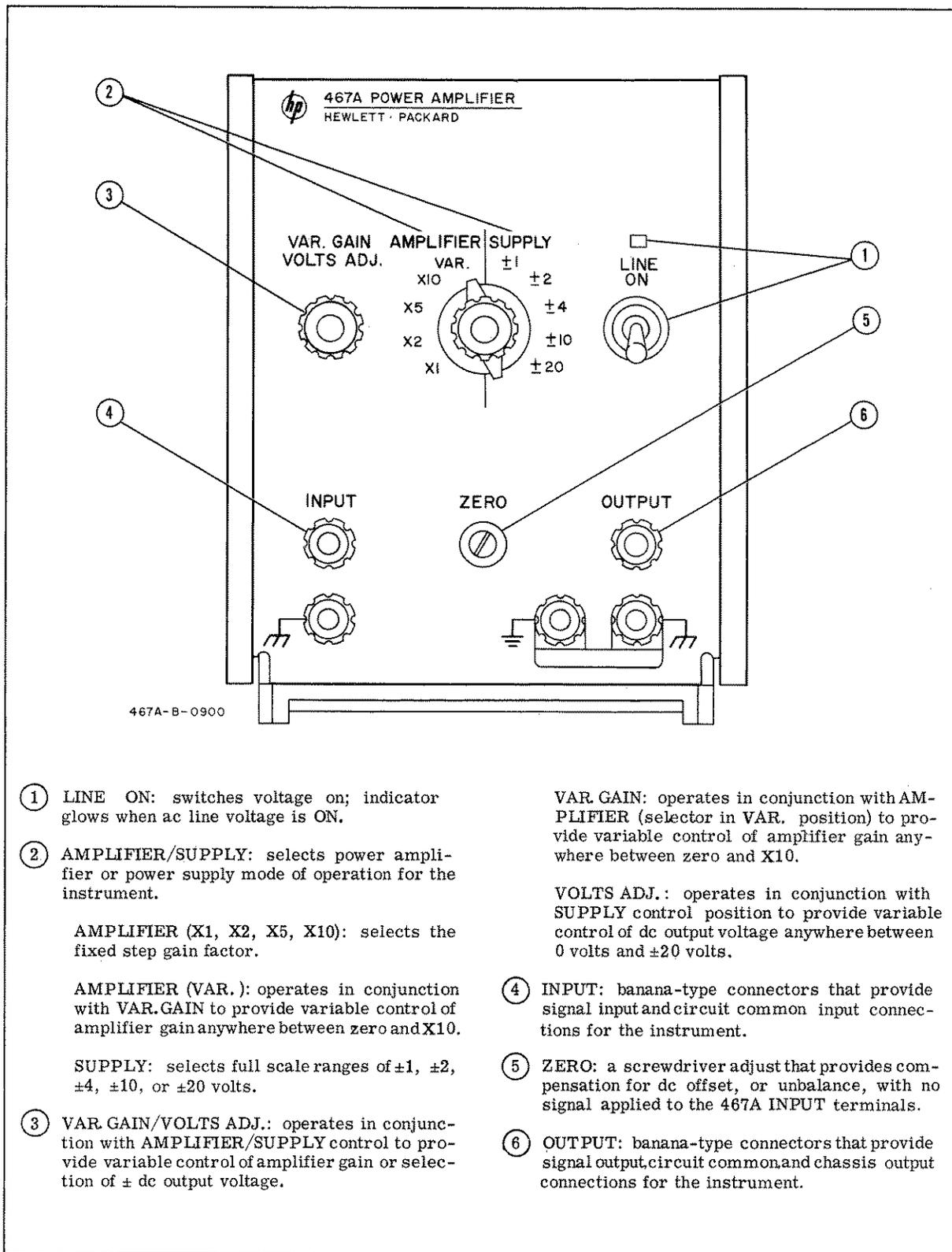
————— NOTE —————

To assure maximum stabilization, allow the instrument to warm up for 30 minutes.

- d. Using the VAR. GAIN VOLTS ADJ. control, adjust the voltage to the desired level.

————— NOTE —————

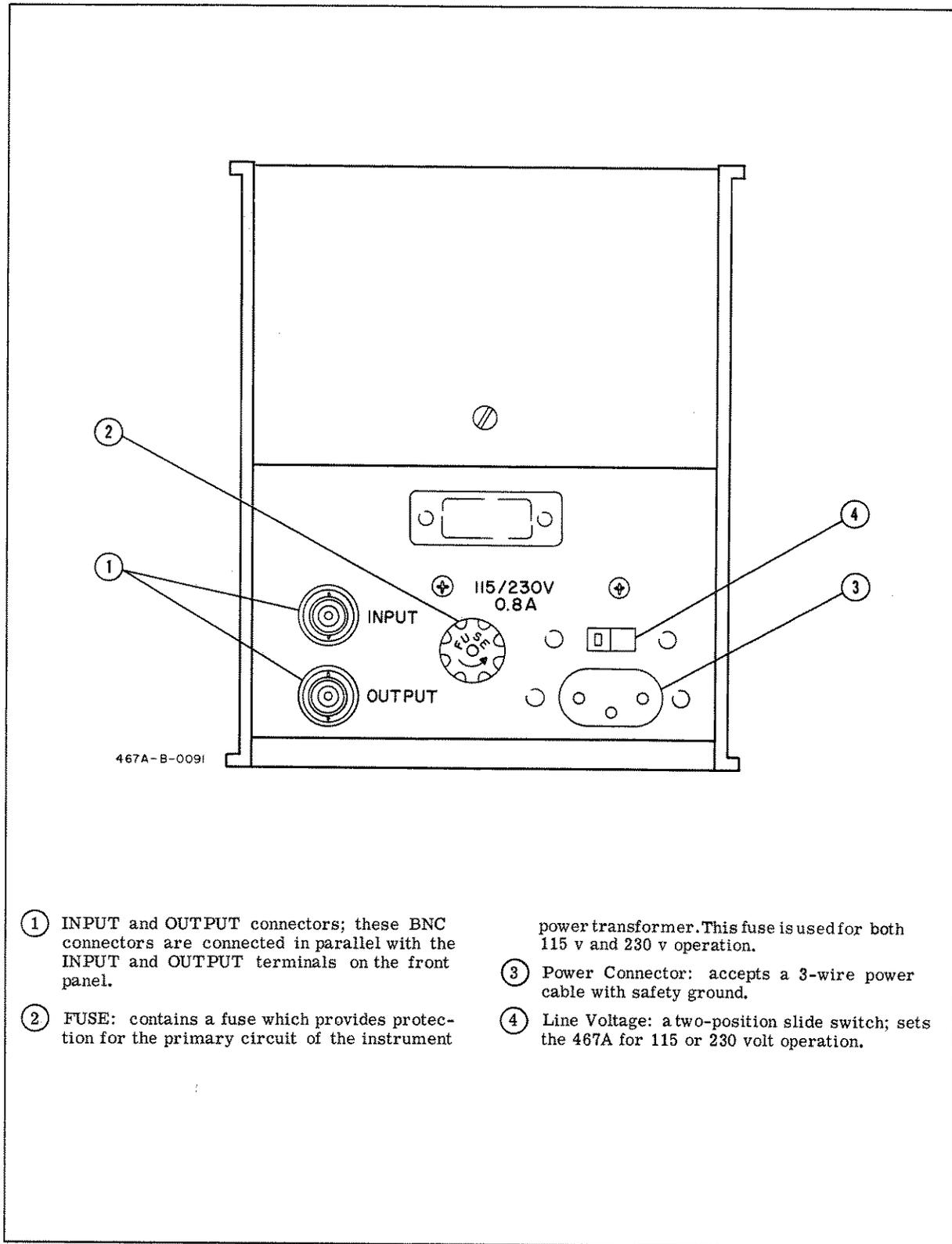
The VAR. GAIN VOLTS ADJ. control is used for both coarse and fine adjustments. Coarse adjust is made after either limit of the fine adjust is reached. Full CCW position produces maximum negative voltage. Full CW position produces maximum positive voltage.



- ① LINE ON: switches voltage on; indicator glows when ac line voltage is ON.
- ② AMPLIFIER/SUPPLY: selects power amplifier or power supply mode of operation for the instrument.  
  
AMPLIFIER (X1, X2, X5, X10): selects the fixed step gain factor.  
  
AMPLIFIER (VAR.): operates in conjunction with VAR.GAIN to provide variable control of amplifier gain anywhere between zero and X10.  
  
SUPPLY: selects full scale ranges of ±1, ±2, ±4, ±10, or ±20 volts.
- ③ VAR. GAIN/VOLTS ADJ.: operates in conjunction with AMPLIFIER/SUPPLY control to provide variable control of amplifier gain or selection of ± dc output voltage.

- VAR. GAIN: operates in conjunction with AMPLIFIER (selector in VAR. position) to provide variable control of amplifier gain anywhere between zero and X10.
- VOLTS ADJ.: operates in conjunction with SUPPLY control position to provide variable control of dc output voltage anywhere between 0 volts and ±20 volts.
- ④ INPUT: banana-type connectors that provide signal input and circuit common input connections for the instrument.
- ⑤ ZERO: a screwdriver adjust that provides compensation for dc offset, or unbalance, with no signal applied to the 467A INPUT terminals.
- ⑥ OUTPUT: banana-type connectors that provide signal output, circuit common, and chassis output connections for the instrument.

Figure 3-1. Front panel Controls, Indicators and Connectors



- ① INPUT and OUTPUT connectors; these BNC connectors are connected in parallel with the INPUT and OUTPUT terminals on the front panel.
- ② FUSE: contains a fuse which provides protection for the primary circuit of the instrument power transformer. This fuse is used for both 115 v and 230 v operation.
- ③ Power Connector: accepts a 3-wire power cable with safety ground.
- ④ Line Voltage: a two-position slide switch; sets the 467A for 115 or 230 volt operation.

Figure 3-2. Rear Panel Controls and Connectors

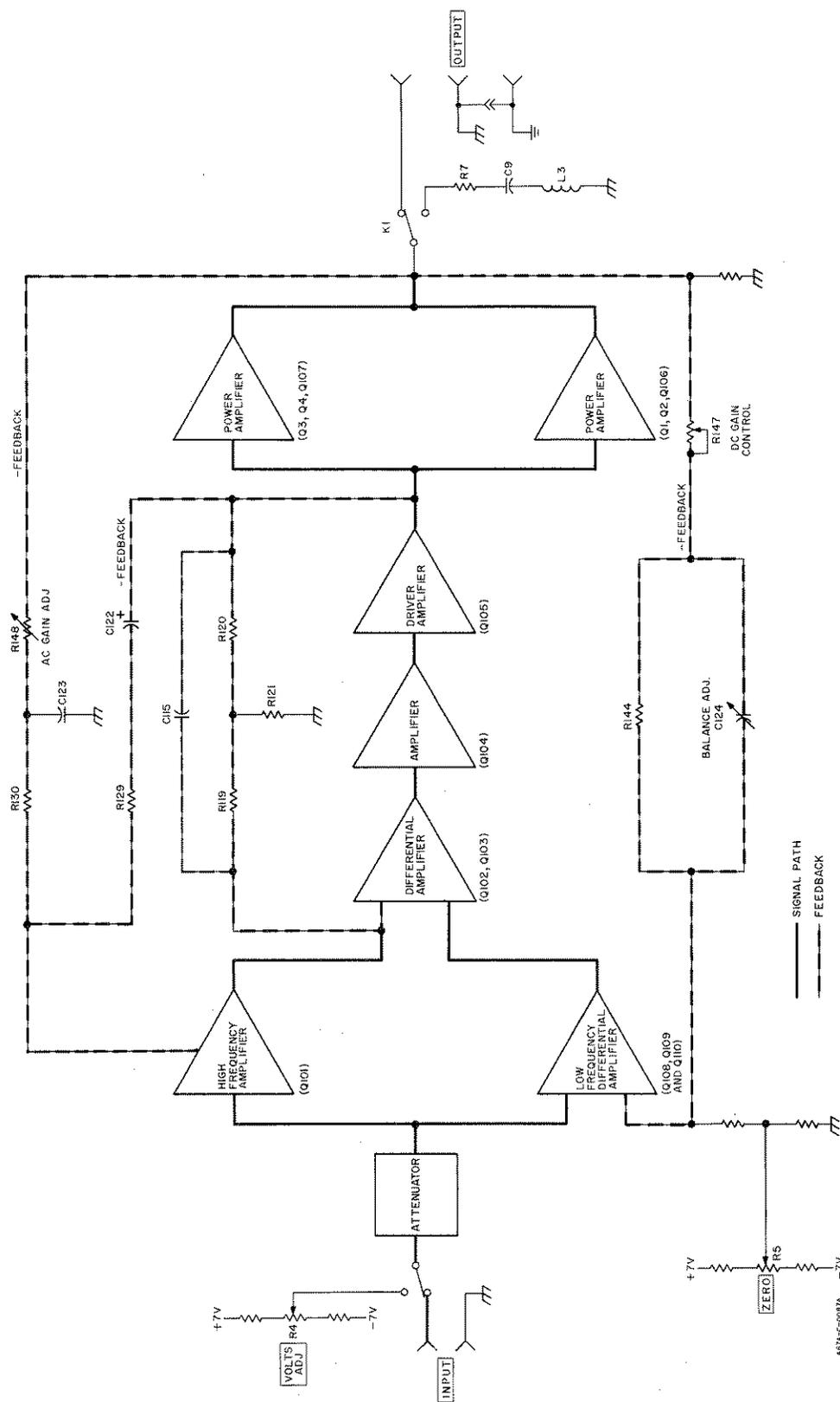


Figure 4-1. Simplified Block Diagram

## SECTION IV

### THEORY OF OPERATION

#### 4-1. INTRODUCTION.

4-2. The Model 467A Amplifier circuits include a high frequency amplifier, a low frequency amplifier, a two-stage differential amplifier, a driver amplifier, and two power amplifier stages. These circuits provide two modes of operation, the power amplifier mode and the power supply mode.

4-3. When the AMPLIFIER/SUPPLY switch is in the AMPLIFIER position, the gain can be set in fixed steps of X1, X2, X5 and X10. When the switch is in the AMPLIFIER/VAR position, the VAR GAIN/VOLTS ADJ control can be used to set the amplifier gain to any value between zero and ten. The input signal is applied to the attenuator, which selects the gain to be used by the instrument amplifier circuitry. Ac and dc feedback stabilize the amplifier gain. Compensation for dc offset, or unbalance, is provided by a ZERO adjust control on the front panel.

4-4. When the AMPLIFIER/SUPPLY switch is in the SUPPLY position, the amplifier provides five power supply voltage ranges:  $\pm 1$ ,  $\pm 2$ ,  $\pm 4$ ,  $\pm 10$  and  $\pm 20$  volts, variable from plus through zero to minus for each range. An internal dc reference voltage (plus or minus) is applied to the amplifier portion, which provides a regulated dc voltage at the OUTPUT terminals of the instrument.

#### 4-5. BLOCK DIAGRAM DESCRIPTION.

4-6. Figure 4-1 shows the block diagram for the 467A. The input signal is applied to the high and low frequency amplifiers. The high frequency amplifier (Q101) amplifies the ac signal; the low frequency amplifier (Q108 through Q110) amplifies the dc and low frequency signals. The amplified input signal is then applied through the differential amplifier (Q102 and Q103), amplifier (Q104), and driver amplifier (Q105) to emitter followers (Q106 and Q107). Power amplifiers Q1 and Q2 (driven by Q106) and Q3 and Q4 (driven by Q107) provide a balanced signal to the OUTPUT connectors.

4-7. At frequencies above 1 MHz, negative feedback from the driver amplifier Q105 is applied to Q101 through C122 and R129 to provide a decrease in distortion and remove the power amplifiers from the feedback loop. Negative feedback from Q105 is applied to differential amplifiers Q102 and Q103 through R120, C115 and R119 to improve frequency response of the instrument. Gain control for high frequency amplifier Q101 is supplied from the output of the power amplifiers (Q1 through Q4) through R148 and R130.

4-8. At frequencies between dc and 50 KHz, negative feedback from the output provides dc gain control and balance adjust for the low frequency amplifiers Q108 through Q110. ZERO adjust R5 provides compensation for dc unbalance of the signal applied to the low frequency amplifiers. Relay K1 protects the external load against current surges during turn-on and turn-off.

#### 4-9. SCHEMATIC DIAGRAM DESCRIPTION.

4-10. The following paragraphs give a detailed description of the Model 467A Amplifier circuits. Refer to Figures 5-13 and 5-14, Section V, for the schematic diagrams of the instrument.

#### 4-11. HIGH FREQUENCY AMPLIFIER.

4-12. Trimmer capacitors C301, C303 and C305 can be adjusted to provide the desired frequency response characteristics for the instrument. Ac input signals from the attenuator are applied through C101 to the high frequency amplifier Q101. The signal is amplified by Q101 and coupled through C104 to the base circuit of Q102. The RC networks, C105, R112, C106 and R114 are used to improve the frequency response characteristics of the amplifier Q102. The bias voltage of Q101 is determined by resistive divider R103 and R104. Ac feedback from power amplifiers (Q1, Q2, Q3, and Q4) is applied through R148 to provide ac gain adjust for Q101.

#### 4-13. LOW FREQUENCY AMPLIFIER.

4-14. When the AMPLIFIER/SUPPLY selector is in the SUPPLY position, +7 and -7 volts are supplied from an internal reference, through resistive dividers, to the amplifier input. Each SUPPLY position ( $\pm 1$ ,  $\pm 2$ ,  $\pm 4$ ,  $\pm 10$  and  $\pm 20$ ) permits setting the dc output voltage to any  $\pm$  value within the range selected. The low frequency amplifier circuit (Q108, Q109 and Q110) amplifies the dc and low frequency input signal and drives Q103. The bias voltage for the low frequency amplifier is controlled by R132 and R133 and the ZERO control R5. Transistor Q110 is a current source for the differential amplifiers Q108 and Q109. Inductors L101 and L102 control the frequency response of the low frequency amplifier (at higher frequencies) by causing degeneration of Q108 and Q109 emitters. High frequencies present at Q109 collector are shorted to ground by C109. Low frequency stabilization and overall amplifier gain (between dc and 50 KHz) are provided by applying dc feedback from the OUTPUT to Q109 base. The ZERO potentiometer R5 provides an adjustment to compensate for dc drift in the instrument. Varying R5 changes the voltage at Q109 base, thereby changing the output level of the low frequency amplifier.

#### 4-15. DIFFERENTIAL AMPLIFIER.

4-16. Differential amplifiers Q102 and Q103 provide an output proportional to the input signals from the high frequency amplifier Q101 and the low frequency amplifier circuit (Q109 and Q110). The high frequency ac signals are coupled to Q102 through C104; the dc and low frequency signals from the low frequency amplifier are direct-coupled to differential amplifier Q103. Capacitor C108 bypasses any high frequency ac from the low frequency amplifier to

ground. C109 bypasses any high frequency signals present at the base of Q103. Ac feedback from Q105 collector circuit is applied through C115 to the base circuit of Q102 for high frequency gain stabilization.

#### 4-17. VOLTAGE AMPLIFIER.

4-18. The voltage amplifier Q104 supplies the majority of the voltage gain for the instrument. Degeneration at low frequencies is provided by R127 in the Q104 emitter circuit; C116 provides added phase stability at high frequencies. Current through R125 provides the bias current for Q105. Breakdown diode CR104 establishes the proper voltage at Q104 collector and maintains a dc signal path from Q104 Collector to Q105 base.

#### 4-19. DRIVER AMPLIFIER.

4-20. Driver amplifier Q105 is driven by current amplifier Q104 and supplies the signal to the power output amplifiers. Transistors Q106 and Q107 are forward biased by diodes CR108 through CR112 and under no-signal condition are conducting slightly to reduce cross-over distortion in the output signal.

#### 4-21. OUTPUT CIRCUITS.

4-22. Transistors Q1 through Q4 provide a complementary symmetry output. Q1 and Q2, driven by emitter follower Q106, provide a low output impedance. Q3 and Q4, driven by Q107, form a unity gain feedback amplifier. This causes Q3 and Q4 to act as a PNP emitter follower, which is necessary to provide the complementary symmetry output.

#### 4-23. EXTERNAL LOAD PROTECTION.

4-24. The external load connected to the 467A is protected during turn-on and turn-off, from current surges and voltage transients, by relay K1. The relay contacts open the circuit to the OUTPUT connectors when the relay is de-energized. When the instrument is turned ON, K1 remains de-energized for about 300 milliseconds. This delay permits the instrument to stabilize before the output is connected to the load. The 300 millisecond delay is caused by the RC time constant of C110 and R161. When the instrument is turned off, the relay quickly de-energizes and opens the circuit to the OUTPUT connector.

### 4-25. POWER SUPPLY CIRCUIT DESCRIPTION.

4-26. The 467A primary power supply consists of two regulated power supplies (-34 and +34 volts), and five reference supplies (+7, -7, +15, -15 and +30 volts). Either 115 or 230 volts ac is connected to the instrument through switch S1 and fuse F1 to T1 primary. Switch S2 (slide switch on rear panel) connects T1 primary windings in series for 230 volt operation, or in parallel for 115 volt operation. The LINE ON lamp DS1 glows when primary power is applied to the instrument.

#### 4-27. MINUS 34 VOLT SUPPLY.

4-28. Transistor Q112 in conjunction with R156, CR129, and CR130 provide a constant current source which provides base drive for Q5 and Q6. Q112 also provides current to keep CR131, CR132, CR133, and CR135 conducting. R2 and Q5 share the load current to reduce the dissipation in Q6. For small load currents Q5 is turned off and resistor R2 supplies the current. As the load current increases, the base of Q5 is forward biased and Q5 conducts, sharing the current. As the load current is increased further, CR134 is forward biased at a current level determined by R159. This will reduce the current in CR135 to zero causing the supply voltage to go to zero also.

#### 4-29. PLUS 34 VOLT SUPPLY.

4-30. The +34 volt supply provides regulated voltage to the power amplifier circuits. Breakdown diode CR143 establishes the reference at the base of Q8. Potentiometer R163 adjusts the current limit setting for the +34 volt supply.

#### 4-31. REFERENCE SUPPLY.

4-32. The diode regulated reference supply (refer to Figure 5-14) provides +7, -7, +15 and -15 voltages. Capacitors C126 and C128 filter the ac voltages. Breakdown diodes CR146 and CR147 maintain a +15 reference voltage at the junction of R149 and R150. The series arrangement of diodes CR120 and CR121 (forward biased diodes) and CR122 and CR123 (reverse biased diodes) compensates for temperature and provides a constant -15 reference voltage at the junction of R151 and R152. The plus and minus 7 volt reference voltages are obtained in the same manner as the plus and minus 15 reference voltages. Series regulator Q111 provides regulated +30 volts to the positive side of the reference supply.