Errata

Title & Document Type: 6823A Power Supply / Amplifier Operating and Service Manual

Manual Part Number: 06823-90001

Revision Date: November 1966

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Agilent Technologies

MODEL 6823A
POWER SUPPLY/AMPLIFIER
HP Part Number 06823-90001

Serials Prefixed 6B, 1150A and Above
(Including Optional Modifications Listed Below)
028

Microfiche No. 06823-90002

Printed: November, 1966
hp Stock Number: 06823-90001

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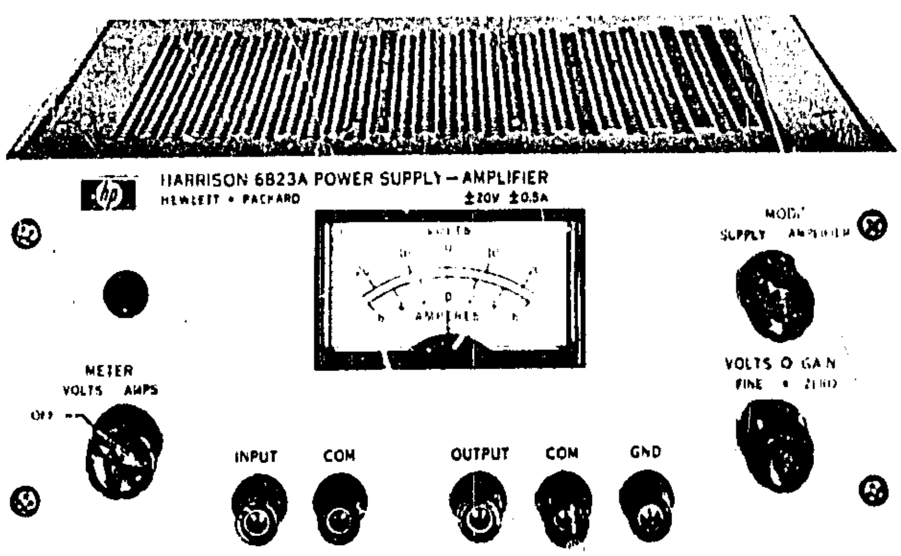


Figure 1-1. DC Power Supply/Amplifier, Model 6823A

SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 The Power Supply/Amplifier (PS/A) shown on Figure 1-1, is a general purpose instrument useful in any laboratory engaged in research and development of electronic systems or components. The PS/A can be operated in one of two basic operating modes; power supply or amplifier. Terminals on the rear barrier strip permit access to various control points within the unit to further expand the operating capabilities of the instrument. The resulting flexibility lends the PS/A to an almost unlimited number of applications. Some of these applications are outlined in Section III of this manual; but a more comprehensive description of the features and applications of the PS/A are included in Application Note 82 published by the Harrison Division. A copy of Application Note 82 can be obtained from your local Hewlett-Packard field office. The following paragraphs describe some of the features of the PS/A both as a power supply and an amplifier.

1-3 POWER SUPPLY FEATURES

1-4 The unit can be made to function as a regulated dc power supply by setting the front panel MODE switch to the SUPPLY position. The supply can furnish either a Constant Voltage output or a Constant Current output (with the addition of an external current sampling resistor). The dc output is bi-polar and is continuously adjustable from its maximum rated positive value to an equal negative value; smoothly through zero with no polarity switch. Both the supply and the load are protected against overloads by a fixed current limit which is set by means of an internal adjustment.

1-5 The supply can be programmed (controlled) at a very high rate of speed (less than 50 μsec for output voltage change over the entire voltage span). The supply can be programmed locally; by means of the front panel control, or remotely; by means of a resistance, voltage, or current source.

1-6 A single meter is used to measure dc output voltage or current. A front panel METER switch allows the dual purpose selection.

1-7 AMPLIFIER FEATURES

1-8 As a power amplifier the unit has a high signal-to-noise ratio (60 db at full output) and an adjustable gain of from 0 to 10 (20 db). The output distortion is low — less than 0.02% at 1 KHz. The amplifier contains a push-pull output stage that can can furnish either a Constant Voltage output or a Constant Current output (with the addition of an external current sampling resistor). The external input can be from either a voltage or a current source. The bandwidth of the amplifier is from dc to 20KHz (±3db).

1-9 The ac component of the output signal can be measured with the front panel meter (Model 6824A only).

1-10 SPECIFICATIONS

1-11 Detailed specification for the PS/A are given in Table 1-1.

1-12 OPTIONS

1-13 Options are factory modifications of a standard instrument that are requested by the customer. The following option is available for the instrument covered by this manual.

Option No.	Description
28	Rewire For 230V AC Input: Supply as normally shipped is wired for 115 Vac input. Option 28 consists of reconnecting the input transformer for 230 Vac operation.

1-14 ACCESSORIES

1-15 The applicable accessories listed in the following chart may be ordered with the instrument or separately from your local Hewlett-Packard field sales office (refer to list at rear of manual for addresses).

ℏp Part No.	Description
14513A	Rack Kit for mounting one 3½" -high unit. (Refer to Section II for details.)
14523A	Rack Kit for mounting two 3½" -high units. (Refer to Section II for details.)
14515A	Rack Kit for mounting one 5¼" -high unit. (Refer to Section II for details.)
14525A	Rack Kit for mounting two 5¼" -high units. (Refer to Section II for details.)

1-16 INSTRUMENT IDENTIFICATION

1-17 Hewlett-Packard instruments are identified by a three-part serial number tag. The first part is the unit model number. The second part is the serial number prefix, which consists of a number-letter combination that denotes the date of a significant design change. The number designates the year, and the letter A through L designates the month, January through December respectively. The third part is the instrument serial number.

1-18 If the serial number prefix on your unit does not agree with the prefix on the title page of this manual, change sheets are included to update the manual. Where applicable, backdating information is given in an appendix at the rear of the manual.

1-19 ORDERING ADDITIONAL MANUALS

1-20 One manual is shipped with each instrument. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and ℏp stock number provided on the title page.

Table 1-1. Specifications

DC POWER SUPPLY	POWER AMPLIFIER
OUTPUT: -20 to +20 Vdc @ 0 to 0.5 amp. LOAD REGULATION: Less than 0.02% plus 5 mV for a full load to no load change in output current. LINE REGULATION: Less than 0.02% plus 5 mV for any line voltage change within the input rating. RIPPLE AND NOISE: Less than 2 mV rms. REMOTE PROGRAMMING: Remote programming of the output at approximately 500 ohms per volt is made available at the rear terminals. PROGRAMMING SPEED: Less than 50μsec are required to program between -20V and +20V. Typically, about 15μsec is required to program between 10% and 90% of the maximum voltage span. TRANSIENT RECOVERY TIME: Less than 100 μsec for output recovery to within 5 mV plus 0.02% following a full load current change in the output.	OUTPUT: 40 volts peak-peak @ 0 to 0.5 amp. VOLTAGE GAIN: Gain is variable 0 to 10 (20db). Output is inverted. FREQUENCY RESPONSE: DC to 20 KHz (±3db) at full output. DISTORTION: Output distortion is less than 0.02% at 1 KHz and maximum rated output. INPUT IMPEDANCE: Approximately 2K ohms. MAXIMUM PHASE SHIFT: At dc — 180° At 100 Hz — 181° At 10 KHz — 205° At 20 KHz — 225°

INPUT: 105-125/210-250 Vac, single phase, 50-440 Hz; 0.33 Amp, 24 Watts maximum.

STABILITY: Less than 0.075% +5 mV total drift for 8 hours after an initial warm-up of 30 minutes at constant line voltage with ambient temperature variations held to ±3°C.

TEMPERATURE RANGES: Operating: 0 to 50°C. Storage: -20 to +85°C.

TEMPERATURE COEFFICIENT: Less than 0.015% plus 1 mV per degree Centigrade.

OUTPUT IMPEDANCE: Less than 0.03 ohm from dc to 100 Hz. Less than 0.3 ohm from 100 to 1000 Hz. Less than 3 ohms from 1000 Hz to 100 KHz.

OVERLOAD PROTECTION: A continuously acting current limiting circuit protects the unit for all overloads including a direct short placed across the output terminals.

METER: The front panel meter can be used as either a -24V to +24V voltmeter or a -0.6 to +0.6 Amp Ammeter.

SIZE: $3\frac{1}{2}$" H x $8\frac{1}{4}$" W x 13" D. Two units can be rack mounted side-by-side in a standard rack panel.

WEIGHT: 16 lbs. net, 20 lbs. shipping.

FINISH: Light gray front panel with dark gray case.

AUXILIARY VOLTAGE SOURCE: Provides +20 Vdc and -20 Vdc at 100 mA. Load regulation is less than 1.3 Vdc, line regulation is less than 0.15 Vdc, and ripple is less than 30 mV peak-to-peak.

2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, proceed as described in the Claim for Damage in Shipment section of the warranty page at the rear of this manual.

2-3 MECHANICAL CHECK

2-4 This check should confirm that there are no broken knobs or connectors, that the cabinet and panel surfaces are free of dents and scratches, and that the meter is not scratched or cracked.

2-5 ELECTRICAL CHECK

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

2-7 INSTALLATION DATA

2-8 The instrument is shipped ready for bench operation. It is necessary only to connect the instrument to a source of power and it is ready for operation.

2-9 LOCATION

2-10 This instrument is air cooled. Sufficient space should be allotted so that a free flow of cooling air can reach the sides and rear of the instrument when it is in operation. It should be used in an area where the ambient temperature does not exceed 50°C.

2-11 RACK MOUNTING

2-12 This instrument may be rack mounted in a standard 19 inch rack panel either alongside a similar unit or by itself. Figures 2-1 and 2-2 show how both types of installations are accomplished.

2-13 To mount two units side-by-side, proceed as follows:

a. Remove the four screws from the front panels of both units.

b. Slide rack mounting ears between the front panel and case of each unit.

c. Slide combining strip between the front panels and cases of the two units.

d. After fastening rear portions of units together using the bolt, nut, and spacer, replace panel screws.

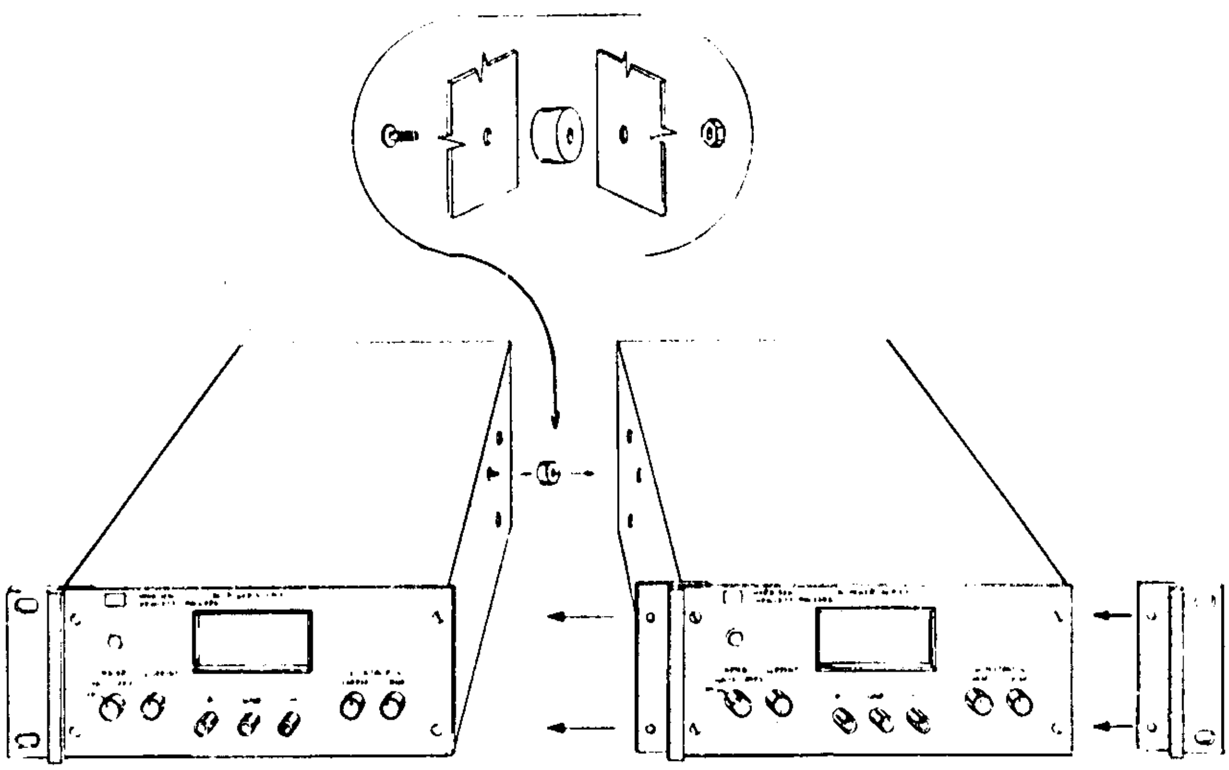


Figure 2-1. Rack Mounting, Two Units

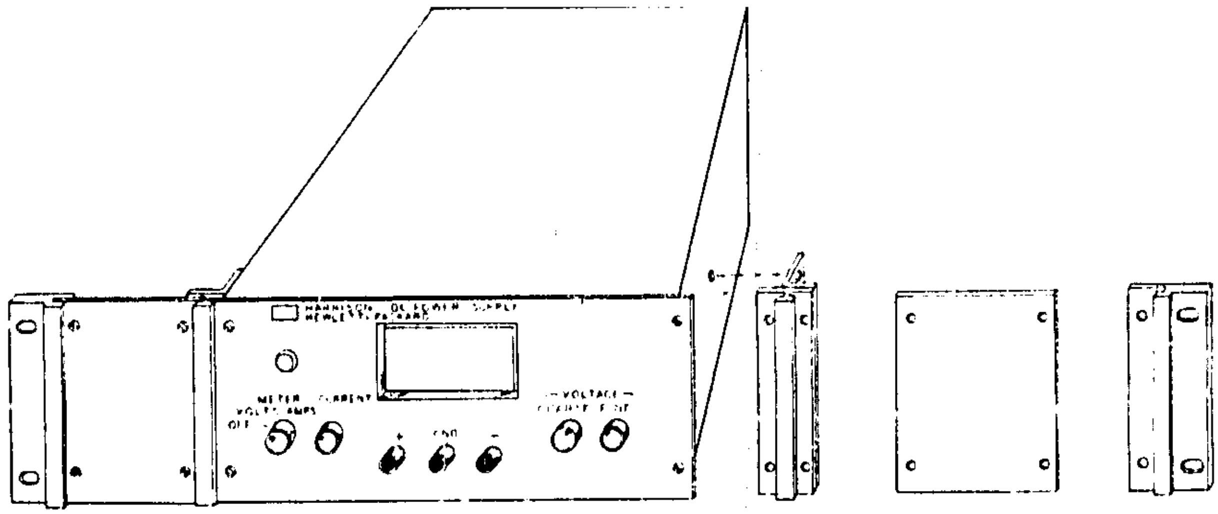


Figure 2-2. Rack Mounting, One Unit

2-14 To mount a single unit in the rack panel, proceed as follows:

a. Bolt rack mounting ears, combining straps, and angle brackets to each side of center spacing panels. Angle brackets are placed behind combining straps as shown in Figure 2-2.

b. Remove four screws from front panel of unit.

c. Slide combining strips between front panel and case of unit.

d. Bolt angle brackets to front sides of case and replace front panel screws.

2-15 INPUT POWER REQUIREMENTS

2-16 This power supply may be operated from either a nominal 115 volt or 230 volt 50-440 cycle power source. The unit, as shipped from the factory, is wired for 115 volt operation. The input power required when operated from a 115 volt 60 cycle power source at full load is 24 watts and 0.33 amperes.

2-17 CONNECTIONS FOR 230 VOLT OPERATION (Figure 2-3)

2-18 Normally, the two primary windings of the input transformer are connected in parallel for operation from 115 volt source. To convert the power supply to operation from a 230 volt source, the power transformer windings are connected in series, as follows:

a. Unplug the line cord and remove the top and bottom covers from unit.

b. Break the printed wiring between 45 and 46 and also between 47 and 48 on the printed circuit board. These are shown in Figure 2-3, and are labeled on printed side of the circuit board.

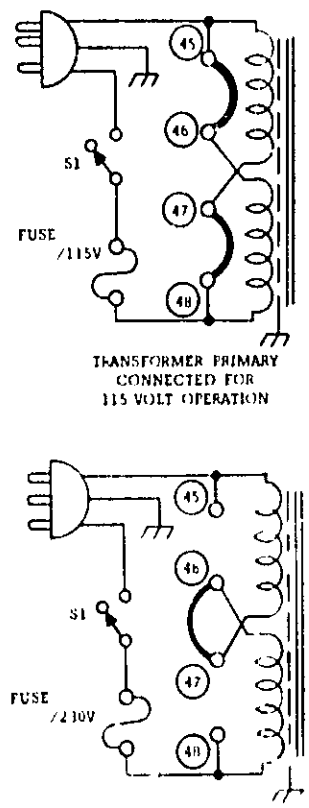


Figure 2-3. Primary Connections

c. Connect a strap between 46 and 47.

d. Replace existing fuse with 1 ampere, 230 volt fuse. Replace covers and operate unit normally.

2-19 POWER CABLE

2-20 To protect operating personnel, the National Electrical Manufacturers Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three conductor power cable. The third conductor is the ground conductor and when the cable is plugged into an appropriate receptacle, the instrument is grounded. The offset pin on the power cable three-prong connector is the ground connection.

2-21 To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter and connect the green lead on the adapter to ground.

2-22 REPACKAGING FOR SHIPMENT

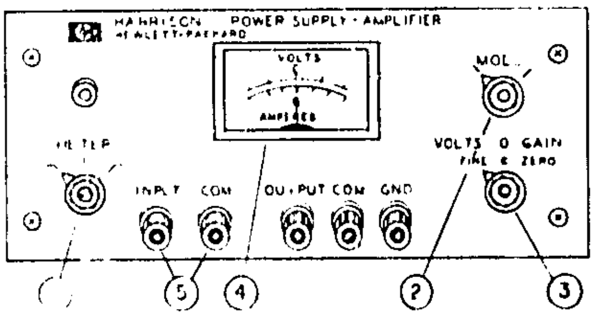
2-23 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped. Be sure to attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

OPERATION

SECTION III
OPERATING INSTRUCTIONS

3-1 OPERATING CONTROLS AND INDICATORS

3-2 The front panel controls and indicators, together with the normal turn-on sequences, for both power supply and amplifier operation are shown on Figure 3-1. These turn-on procedures are performed utilizing the normal rear terminal strapping connections as received from the factory.



TURN-ON SEQUENCE - POWER SUPPLY

1. SET AC LINE SWITCH TO ON AND OBSERVE THAT PILOT LIGHT GOES ON
2. SET METER SWITCH (1) TO DC VOLTS.
3. SET MODE SWITCH (2) TO SUPPLY.
4. ADJUST VOLTS GAIN CONTROL (3) CLOCKWISE OR COUNTERCLOCKWISE UNTIL DESIRED POSITIVE OR NEGATIVE OUTPUT VOLTAGE, RESPECTIVELY, IS INDICATED ON FRONT PANEL METER (4). CONCENTRIC FINE-ZERO CONTROL (3) PROVIDES FINE CONTROL OF THE OUTPUT VOLTAGE.
5. SHORT CIRCUIT OUTPUT TERMINALS; SET METER SWITCH TO AMPS AND OBSERVE SHORT CIRCUIT OUTPUT CURRENT ON METER. CURRENT LIMIT IS FACTORY ADJUSTED SO THAT METER SHOULD INDICATE FULL SCALE DEFLECTION.
6. REMOVE SHORT AND CONNECT LOAD TO OUTPUT TERMINALS (FRONT OR REAR).

TURN-ON SEQUENCE - AMPLIFIER

1. TURN ON UNIT AND SET MODE SWITCH (2) TO AMPLIFIER.
2. CONNECT INPUT SIGNAL SOURCE TO INPUT (5) TERMINALS (FRONT OR REAR).
3. ADJUST VOLTS/GAIN CONTROL (3) FOR DESIRED GAIN (0 TO 10). CONCENTRIC FINE/ZERO CONTROL PERMITS AVERAGE OUTPUT TO BE ADJUSTED TO ZERO.
4. MEASURE OUTPUT VOLTAGE WITH EXTERNAL VOLTMETER FOR 6823A UNITS OR FOR 6824A UNITS, SET METER SWITCH (1) TO AC VOLTS AND READ OUTPUT DIRECTLY ON FRONT PANEL METER.
5. CONNECT LOAD TO OUTPUT TERMINALS (FRONT OR REAR).

Figure 3-1. Front Panel Controls and Indicators

3-3 OPERATING MODES

3-4 The position of the front panel MODE switch determines whether the instrument will be used as a power supply or an amplifier. Terminals on the rear barrier strip, which connect into various control points within the unit, allow strapping connections to be made which enable the power supply or amplifier to be utilized in an almost unlimited number of applications. The following paragraphs describe the procedures for utilizing some of the features which will suggest many related applications.

3-5 However, the configurations shown in the succeeding paragraphs by no means exhaust the various modes in which the PS/A can be used. The reader is encouraged to consider this instrument in terms of operational amplifier techniques; this viewpoint will suggest and facilitate many other areas of application. Many such possibilities are suggested by handbooks on operational amplifiers (e.g., "Handbook of Operational Amplifier Applications" — Burr-Brown Research Corporation, Copyright 1963).

3-6 Such handbooks suggest how operational amplifiers can be used as integrators, differentiators, ramp function generators, etc.; with the PS/A, these techniques are extended to previously unattained power levels.

3-7 An alternate viewpoint is to consider the PS/A as a general-purpose DC coupled precision power transducer capable of accepting either resistance, voltage, or current input (AC and/or DC) and delivering a power output, Constant Voltage or Constant Current, AC and/or DC.

3-8 Application Note 82, published by the Harrison Division, presents a more detailed approach concerning the operational features and related applications of the PS/A unit. A copy of this note can be obtained from your local Hewlett-Packard field office.

3-9 GENERAL NOTES AND OPERATING CONSIDERATIONS

3-10 DIAGRAMS

3-11 All of the following diagrams show the necessary barrier strip connections, as well as a simplified circuit diagram showing how the major internal components of the unit are connected for that strapping arrangement. The diagrams also include all components which must be added externally to the unit. The barrier strip portion of each diagram is correct for all PS/A Series instruments, but when implementing these strapping patterns, check whether the terminal locations are the same as shown in the following diagrams, which are based specifically on the Model 6823A. In any case, the terminal designations are correct for all PS/A Series instruments and should be followed regardless of their location.

3-12 Unless otherwise indicated, the configurations shown have been selected so that operation is independent of whether the front panel MODE switch is in the power SUPPLY or AMPLIFIER position.

3-13 EXTERNAL RESISTORS

3-14 External resistors and potentiometers should be wire-wound and have a temperature coefficient of less than 20ppm/°C. They should operate at less than 1/30th (preferably 1/100th) of their wattage rating in order to minimize short term "bobble" associated with elevated surface temperature.

3-15 CONNECTING LEADS

3-16 Shielded leads should be used for all barrier strip connections, except that twisted leads may be used from the "Common" and "Output" terminals to the load. The outer sheath of the shielded wire should never be used as a conductor, but should be connected at the unit end only to the terminal designated "Common".

3-17 Best high speed programming and wide band amplifier operation will be achieved when the load is connected at the rear terminals rather than at the front. Any capacitance in parallel with the load device should be minimized, since this capacitance will limit the high frequency bandwidth.

3-18 Ensure that the screws on the rear terminals are tightened securely before power is applied to the unit.

3-19 FINE/ZERO CONTROL

3-20 The front panel Fine/Zero control is operable for all modes. In the power supply mode, it acts as a fine control on the DC output. In remote programming and amplifier modes, it provides a DC "offset" adjustment of approximately 1% of the maximum rated output voltage. Thus, this control permits the accurate setting of zero output voltage with zero ohms programming.

3-21 GROUND LOOPS

3-22 If excessive 60 H_z component exists on output, check for ground loops. The system in which the PS/A is employed should have one ground point only. See the Harrison Division's power supply Application Manual, Sections D1a (6) and D1d, for further discussion of typical ground loop problems.

3-23 REVERSE CURRENT LOADING

3-24 An active load connected to the unit may actually deliver a reverse current during a portion of it's operating cycle. An external source cannot be allowed to pump current into the instrument without the risk of possible damage. To avoid damage it is necessary to preload the unit with a dummy load resistor so that it will deliver current through the entire operating cycle of the load device.

3-25 In general, the load resistor that is added should draw a current equal to the peak current which otherwise would be forced back into the PS/A. This means that the current rating of the PS/A instrument used must be equal to, or greater than, the sums of the absolute values of the output and reverse currents.

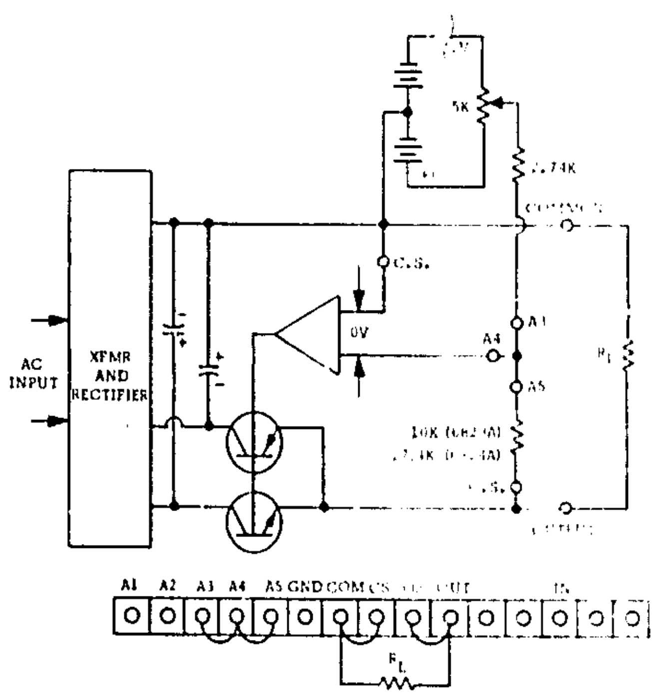


Figure 3-2. Standard Power Supply Operation (CV)

3-26 CONSTANT VOLTAGE OPERATING MODES

3-27 NORMAL OPERATING MODES

3-28 Figure 3-2 shows the circuit configuration and normal rear barrier strip strapping pattern for standard power supply operation. The front panel MODE switch is in the SUPPLY position. The DC output is continuously adjustable from its maximum rated positive value to an equal negative value — smoothly through zero with no polarity switch.

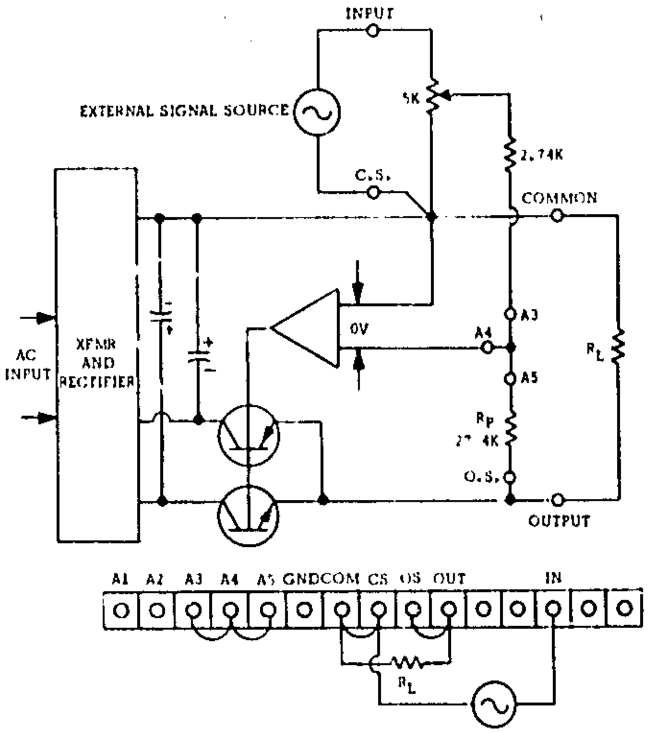


Figure 3-3. Standard Amplifier Operation (CV)

3-29 Similarly, Figure 3-3 shows the circuit configuration and strapping pattern for standard amplifier operation. The external oscillator must have a voltage output which is at least 1/10th of the peak output voltage desired; its current capability must be at least 600μa for each volt input — in other words, the oscillator faces an input impedance of approximately 1.7K. The front panel gain control permits the amplifier gain to be set anywhere from zero to X10, although the gain setting will not be a linear function of control rotation. The front panel FINE/ZERO control permits the dc component of the output to be adjusted approximately 1% of the voltage rating of the instrument, thus enabling the average output value to be adjusted exactly to zero (assuming the input signal has either no dc component or only a small dc component). If desired, a coupling capacitor can be added to block any large input dc components, although in many applications this capacitor will be omitted so that the PS/A can amplify <u>all</u> input signal components, both dc and ac.

3-30 REMOTE SENSING

3-31 In normal operation, a power supply develops an IR drop in the leads connecting it to the load. This reduces the output voltage actually present at the load terminals and also degrades the load regulation performance.

3-32 Sensing terminals permit the feedback amplifier to sense at the load terminals instead of at the PS/A output terminals. This configuration is shown in Figure 3-4 and is applicable for all Constant Voltage modes of operation, both power supply and amplifier. Moreover, the strapping pattern shown in Figure 3-4 can be combined with any of the Constant Voltage diagrams shown elsewhere in the manual in order to achieve optimum performance at the load terminals.

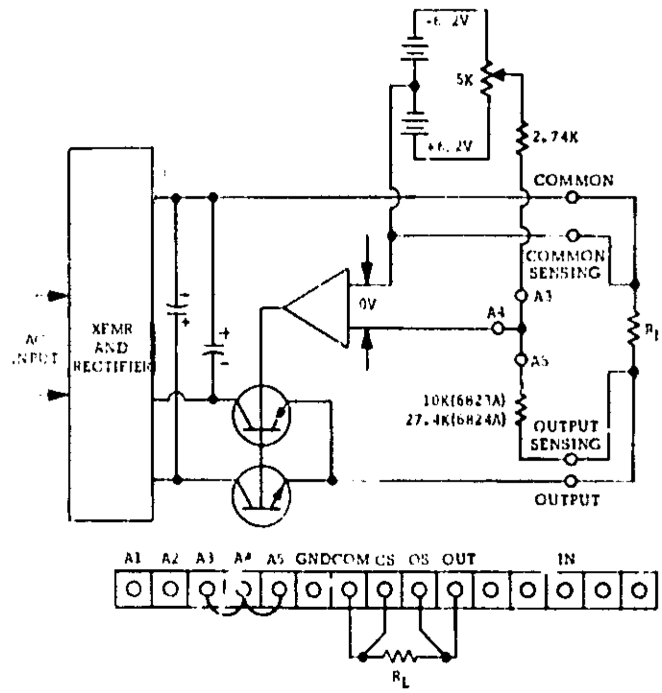


Figure 3-4. Remote Error Sensing

3-33 This does not mean that remote sensing can be used to compensate for an unlimited IR drop between the Common and Output terminals and the load. Any voltage lost in this way detracts directly from the output voltage available for the load. Furthermore, proper operation of the PS/A is insured only if the IR drop in the Common lead is less than, or equal to, one volt.

3-34 If external switching schemes are employed in conjunction with remote sensing, care must be taken that each sensing lead is not momentarily open circuited with respect to the corresponding output terminal. Such open circuit conditions can result in the power supply delivering excessive voltage and/or current to the load, risking damage to both the PS/A and the load device. If it is impossible to insure that an open sensing lead condition will not occur, it is recommended that a 100 ohm, 1/2 watt resistor be connected from "Common" to "Common Sensing", and a similar resistor from "Output" to "Output Sensing". This will minimize voltage and current transients if the sensing leads should accidentally become open circuited. All sensing leads should be shielded.

3-35 REMOTE PROGRAMMING, POSITIVE OUTPUT

3-36 Figure 3-5 shows the strapping pattern and associated circuit configuration for remote programming Power Supply / Amplifiers for positive Constant Voltage DC output at the rate of 500 ohms/volt. The programming control Rp should be wire-wound and selected in accordance with paragraph 3-13. Its dissipation can be computed by remembering that the current through Rp is 2 MA.

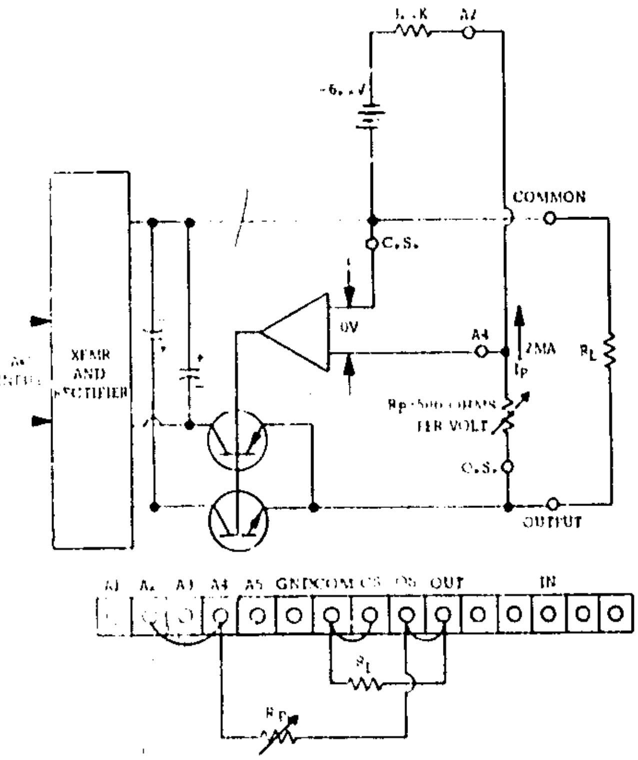


Figure 3-5. Remote Resistance Programming, Positive Output

3-37 Figure 3-6 shows two resistance programming characteristics which are typical (although somewhat exaggerated) of the performance without programming alignment. The output voltage with zero programming always will differ from zero, being either positive (B) or negative (A), and the maximum output voltage will be achieved with a value of programming resistance not predicted by the programming coefficient.

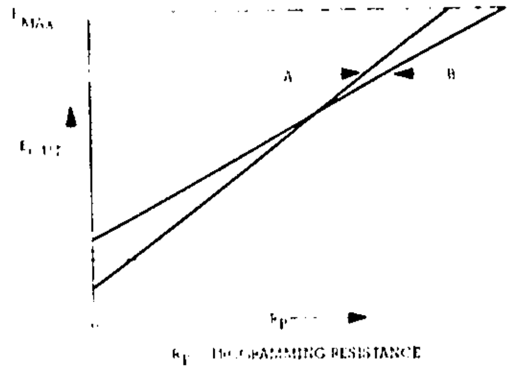


Figure 3-6. Unaligned Resistance Programming Characteristics

3-38 Notice, however, that even with an unaligned instrument the typical characteristics of A and B are extremely linear — that is, there is no curvature. To convert either of the characteristics of Figure 3-6 to the desired programming characteristic of Figure 3-7, it is necessary to adjust both the zero crossing and the angle of slope of the programming characteristic.

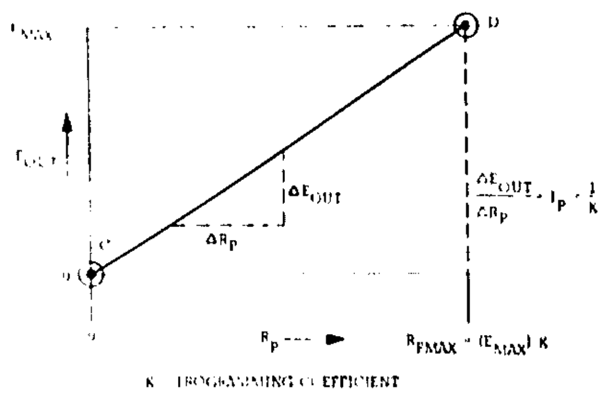


Figure 3-7. Aligned Resistance Programming Transfer Function

3-39 In the PS/A Series the zero crossing is adjusted by means of the front panel FINE/ZERO knob, while the slope of the programming function is adjusted by means of an internal control, R_{38}. First the zero crossing is adjusted; then a programming resistance, which according to the programming coefficient (500 ohms/volt) should yield the maximum rated output voltage for the instrument, is connected to the programming terminals, and R_{38} is adjusted until the output voltage is exactly equal to the maximum rated value. Since the two adjustments are mildly interdependent, it is necessary to repeat this procedure once.

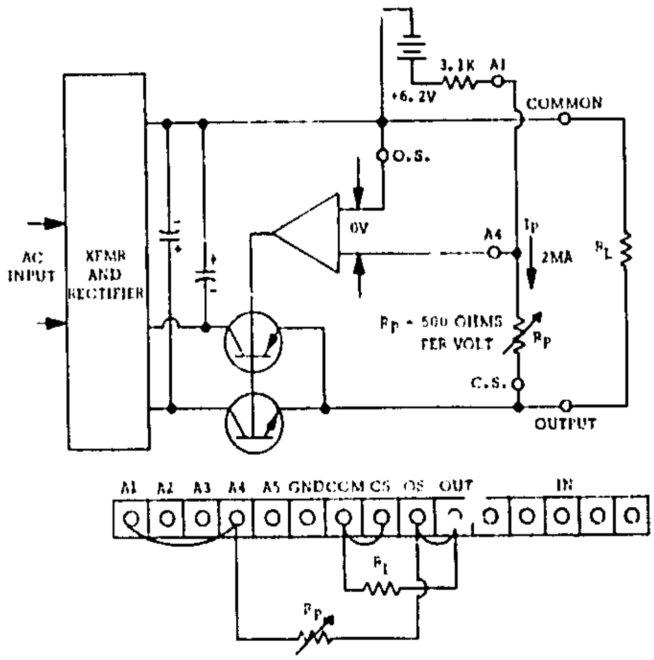


Figure 3-8. Remote Resistance Programming, Negative Output

3-40 REMOTE PROGRAMMING, NEGATIVE OUTPUT

3-41 Figure 3-8 is the same as Figure 3-5 except that the linearly programmed output voltage is negative. The internal programming slope adjustment for a negative output is R_{39}.

3-42 REMOTE PROGRAMMING, BIPOLAR OUTPUT

3-43 The circuits of Figures 3-5 and 3-8 can be combined to yield a power supply which is programmable in either direction, depending upon the position of switch S1 (see Figure 3-9). One obtains a linearly programmed negative DC output when switch S1 is connected to A1; and a positive output when connected to A2. Switch S1 must be a break-before-make switch.

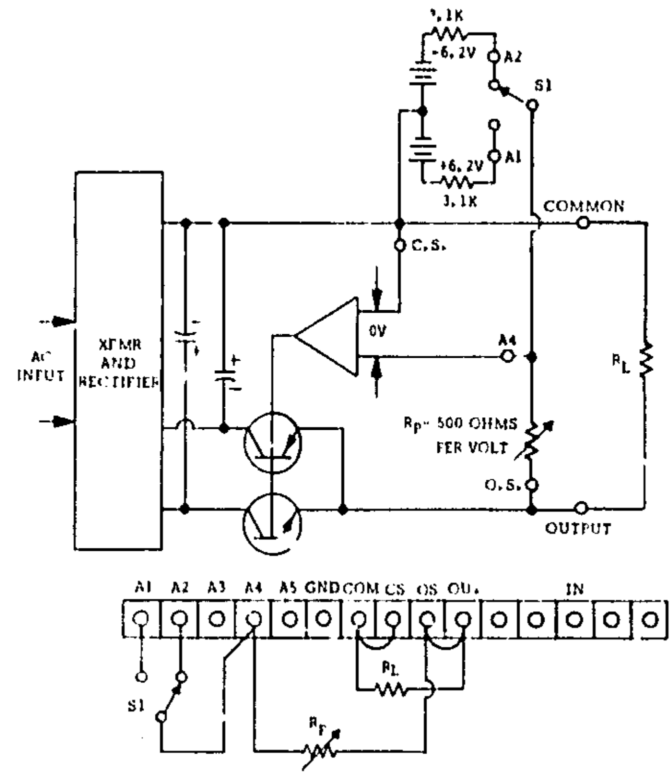


Figure 3-9. Remote Resistance Programming, Bi-Polar Output (CV)

3-44 The advantage of the configuration of Figure 3-9 is that the output is linearly programmed in both directions. The disadvantage is that a switch must be used in order to reverse the output polarity.

3-45 If it is desired to achieve accurate programming reproducibility, or if it is necessary to repeatedly set the power supply output to specific voltage values, either of the substitute arrangements suggested by Figure 3-10(B) and 3-10(C) may be employed in place of the rheostat Rp. Suppose, for example, it is decided to set the power supply over the span from 0-20V. If continuous adjustment is required, the best choice would be a 10K rheostat (since the programming coefficient is 500 ohms/volt). But if specific tests must be made at 0, 5, 10, 15, and 20V, the arrangement shown in Figure 3-10(B) should be employed, using a make-before-break switch. If the same voltage values are desired, but not in ascending or descending sequence, the terminals from the resistor string can be connected to the switch in any desired sequence, as suggested by Figure 3-10(C).

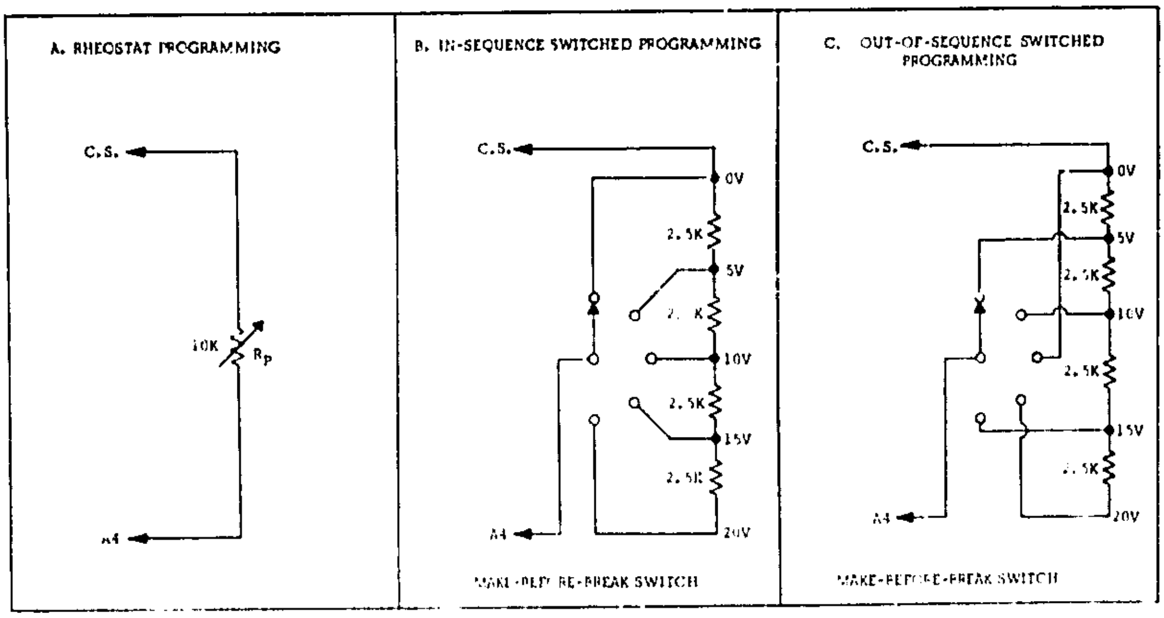


Figure 3-10. Switched Resistor Substitutes

3-46 These substitute configurations for Rp can be employed with any of the diagrams in this section. In all such applications a make-before-break switch must be used so that output voltage transients will not occur during the switching interval. Such transients can lead to damage to both the load and the power supply.

3-47 SWITCHLESS BIPOLAR PROGRAMMING

3-48 Figure 3-11 shows how to resistance program a PS/A for continuously variable output dc voltage, remotely controlled, without need for a polarity switch. Clockwise rotation of the 10K potentiometer will result in a positive output equal to the maximum voltage capability of the instrument.

3-49 The advantage of Figure 3-11 is that the output is continuously variable through zero with one control. The disadvantage is that the output is not a linear function of the rotation of potentiometer R_Q. Note, however, that in many applications it is not necessary that the programming function be linear, just reproducible. The power supply can be switched readily to positive or negative values (and later reset precisely at these same values) by substituting a switched resistor network for R_Q. The switch must be a break-before-make type.

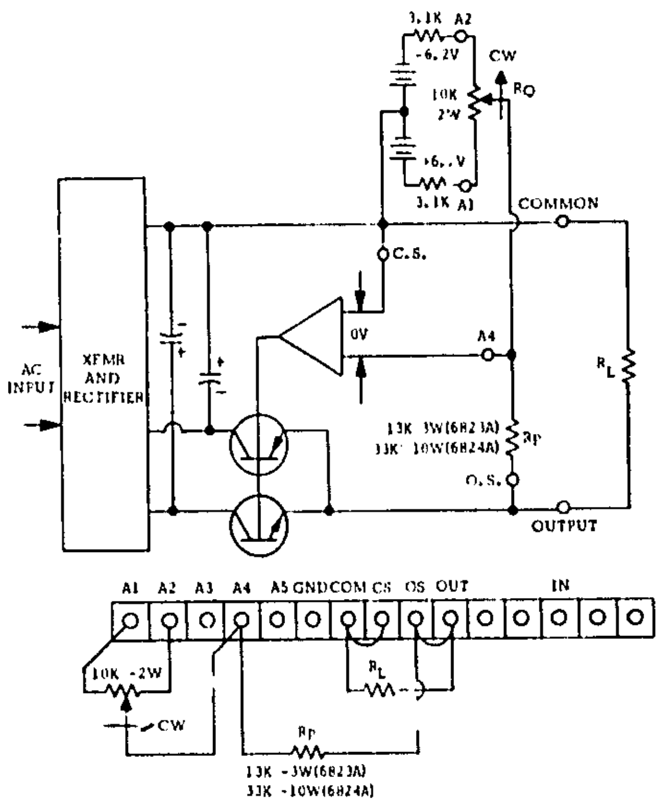


Figure 3-11. Bi-Polar Programming (Constant Voltage)

3-50 POWER SUPPLY WITH SUPERIMPOSED AC OUTPUT

3-51 In some applications it is desirable to add an AC component to the adjustable DC output of a Constant Voltage power supply. Figure 3-12 shows how this can be done.

3-52 The PS/A is operated as a normal power supply from the front panel with the MODE switch in the SUPPLY position. The amplitude of the added AC component is controlled by adjusting R_Y. The value of this resistor should be greater than the minimum load resistance which the external signal source is suited to drive, since the impendance looking into terminals C.S. and A4 is virtually zero ohms.

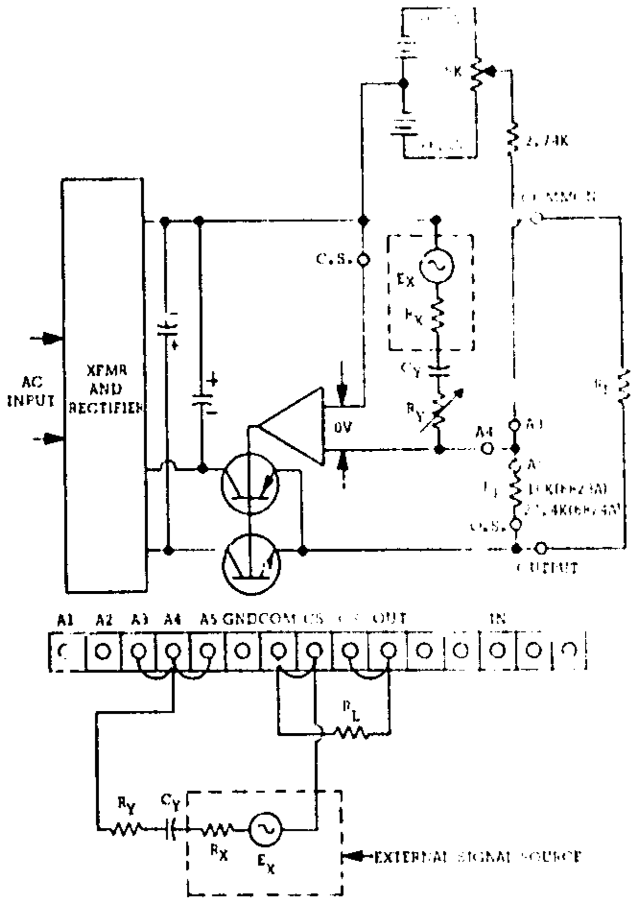


Figure 3-12. Constant Voltage Supply With Superimposed AC Output

3-53 The amplitude of the ac Output component is given by $E_{AC} = E_X (R_p/R_X + R_y)$, where R_X is the internal (Thevenin equivalent) source resistance. The capacitor C_Y is added in order to block the DC current path through the oscillator, and must be selected large enough to pass the lowest frequency of interest. The low frequency 3 db down point will be at $f = \frac{1}{2\pi(R_X + R_Y)\, C_Y}$.

3-54 CONSTANT VOLTAGE AMPLIFIER WITH REMOTE GAIN CONTROL

3-55 The PS/A can be used as a power amplifier with Constant Voltage output that can be remotely controlled in a linear manner if the strapping arrangement shown on Figure 3-13 is employed. With this configuration, the gain is a linear function of control rotation, and the gain control is a linear function of control rotation, and the gain control is external to the PS/A. E_X and R_X are the equivalent (open circuit) voltage and output resistance looking back into the external signal source. R_Y must be selected to have a value at least as large as the minimum load resistance which the external signal source can feed without overloading or distorting. C_Y is inserted in order to block any small DC currents which otherwise might flow from the oscillator, producing a DC component on the output. C_Y must be selected large enough to pass the lowest frequency of interest; the 3 db down frequency is

$$f = \frac{1}{2\pi\,(R_X + R_Y)\, C_Y}.$$

3-56 If it is desired to amplify a DC signal, or one which has both a DC and AC component, then the capacitor C_Y must be eliminated from the circuit.

3-57 The output voltage is given by the equation

$$E_O = E_X \frac{R_p}{R_X + R_Y}.$$

Proper impedance levels will be maintained if approximately 2 mA is allowed to flow through R_Y and R_p. Thus wherever possible, R_Y should be selected so that

$$R_Y = \frac{E_X}{2\,(10^{-3})} - R_X$$

where the E_X for this equation is the maximum <u>peak value</u> which will be amplified. This equation, of course, assumes that the external signal source is capable of delivering 2 mA without overloading or distorting, and should be altered if less current is available.

3-58 Current Input. Actually, the components E_X, R_X, and R_Y of Figure 3-13 comprise a current source feeding the summing point A4 and the gain control R_p. A current source can be substituted in place of these components, and the output voltage will be $V_{OUT} = I_X R_P$, where I_X is the current source connected between CS and A4. As shown in Figure 3-13. The capacitor C_Y should also be added in series if it is desired to suppress any DC component present in the input signal source.

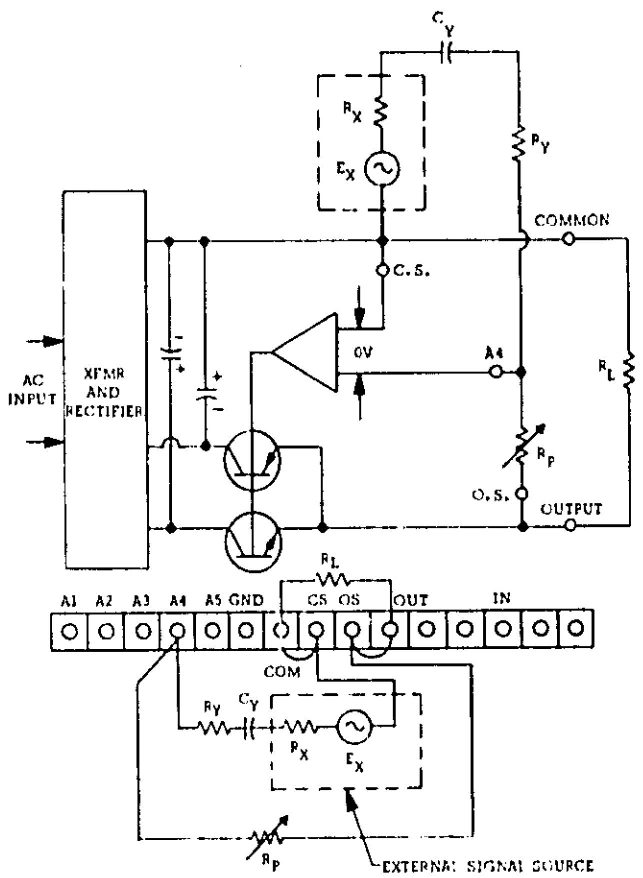


Figure 3-13. Constant Voltage Amplifier With Linear Remote Gain Control

3-59 Two or More Inputs. The concept of Figure 3-13 is readily adapted, using standard operational amplifier techniques, to the simultaneous amplification of two or more signals. Figure 3-14 shows the manner in which two voltage inputs can be mixed and amplified; additional inputs can be added in parallel without limit, and current input signals can be substituted for voltage input signals, as discussed in the previous paragraph. The capacitors C_Y and C'_Y are only included when it is desired to:

a. Prevent the DC input level of the signal from affecting the DC level of the output, or

b. Prevent the DC level of the PS/A from being fed back into the output terminals of the signal source.

3-60 The output for two (or more) inputs is given by:

$$E_O = E_X \frac{R_P}{R_X + R_Y} + E_X' \frac{R_P}{R_X' + R_Y'} + \ldots$$

Thus R_Y, R_Y' can be made variable and used as relative level controls while R_P functions as a master gain control. Notice that any of the signal inputs which are to be mixed and amplified may be ac, dc, or both.

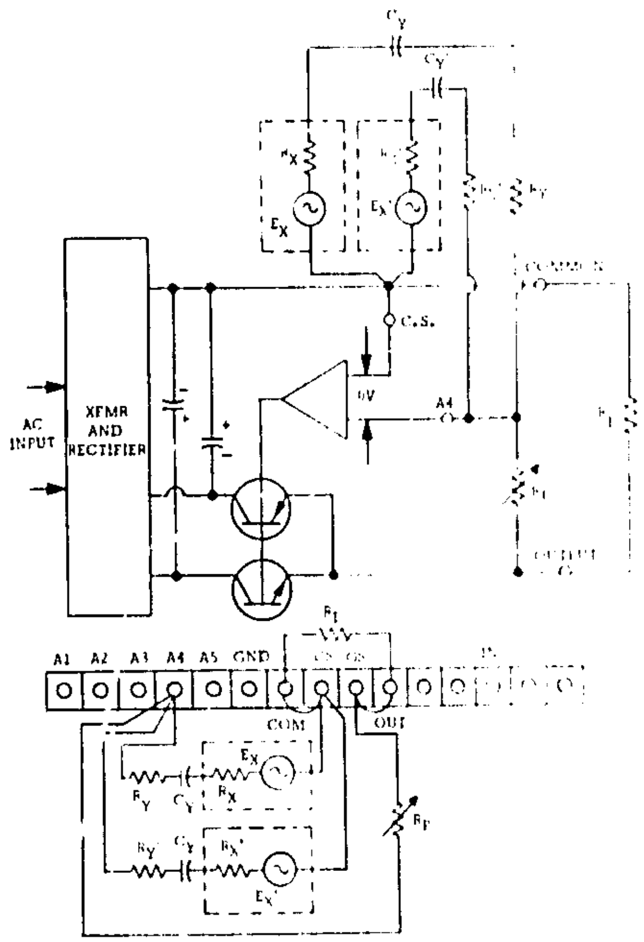


Figure 3-14. Constant Voltage Amplifier, Two Inputs

3-61 CONSTANT CURRENT OPERATING MODES

3-62 In order to achieve constant current operation, it is necessary to utilize an external current sampling resistor which yields a voltage drop that is proportional to the output current. This voltage drop can then be applied to the comparison amplifier in the input circuit and compared with a fraction of the reference voltage (or input voltage). The output of the comparison amplifier is then fed back to the regulator/output amplifier in a manner identical to that occurring during constant voltage operation. Hence, the only conceptual difference between Constant Current operation and Constant Voltage operation is that the voltage which is sensed by the comparison amplifier is taken across the current sampling resistor rather than across the load.

3-63 The regulation ripple, temperature coefficient, and stability of Constant Current Power Supply/Amplifier performance can be predicted by dividing the corresponding Constant Voltage specification by the ohmic value of R_S. For example, the use of a 2 ohm current sampling resistor converts the 2 mV rms Constant Voltage ripple and noise specification of the 6823A to 1 MA, etc. In the case of temperature coefficient and stability, it is also necessary to add in the percentage effect due to any change in ohmic value of the monitoring resistor R_S.

3-64 The output impedance of the Constant Current source at DC is given by the relationship $Z_O = (\Delta E_L/\Delta I_L)$, where ΔE_L is the change in load voltage associated with a load resistnace change, and ΔI_L is the small resulting output current change. The fact that the PS/A has a high loop gain and no output capacitor means that the PS/A used in a Constant Current mode will have a high output impedance. In fact, it can be shown that the impedance at any frequency for a Constant Current source of this type will be approximately equal to R_M (AB), where AB is the loop gain of the feedback amplifier within the power supply at the frequency of interest. Since the PS/A has a bandwidth in excess of 20 KHz, this output impedance will remain quite high over a wide frequency band. Stated in terms of the time domain, the PS/A will respond quickly to changes in load resistance — the load current transient will be short.

3-65 SELECTING R_S

3-66 Particular care must be paid to the manner in which the current sampling resistor, R_S, is selected and employed. Constant Current operation, on a percentage basis, can be no better than this resistor.

3-67 R_S is selected to yield a 1 volt drop at the maximum current rating of the instruments; its maximum dissipation is 1/2 watt for the Model 6823A and 1 watt for the Model 6824A. It is therefore recommended that a minimum 30 watt wire-wound resistor be used for the former and 60 watt for the latter. This ensures that the surface temperature of the resistor will not be high compared to the ambient, and therefore subject to long-term warm-up effects and short-term variations resulting in output "bobble". In any case, the temperature coefficient of the resistor should be 20 ppm/°C or less.

3-68 If it is intended to use the PS/A at less than maximum rated output current, proportionately higher values of R_S may be chosen. This will result in better performance at low currents. It should be remembered, however, that the resistor R_S cannot be increased in ohmic value indiscriminately for two reasons:

a. It soon becomes impractical to increase the wattage rating of R_S by the necessary amount.

b. The IR drop which occurs across R_S detracts directly from the power supply voltage rating available to the load device.

3-69 Resistor R_S should be a four terminal device connected as shown on Figure 3-15. Note that for convenience and clarity, the remaining Constant Current diagrams do not show this connection pattern explicitly.

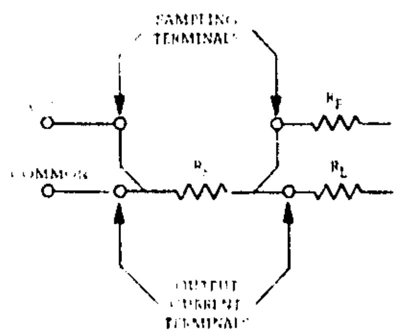


Figure 3-15. Current Sampling Resistor, Connection Method

3-70 NORMAL OPERATING MODES

3-71 Figure 3-16 shows the connection pattern and associated circuit configuration for operating the PS/A as a continuously variable, reversible DC Constant Current source. This is the Constant Current counterpart of the Constant Voltage mode of operation shown in Figure 3-2. The MODE switch is in the SUPPLY position.

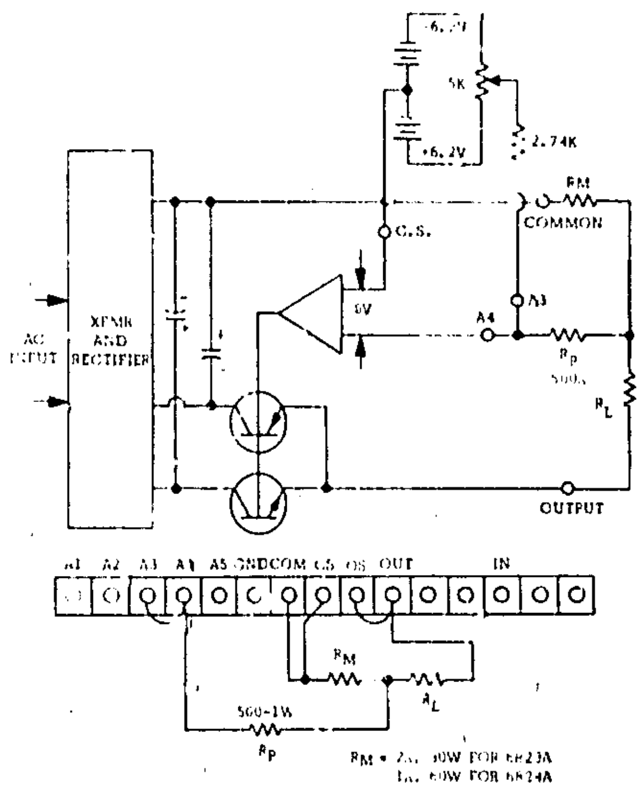


Figure 3-16. Standard Constant Current Power Supply

3-72 Figure 3-17 shows the simplest way of operating the PS/A as a Constant Current output amplifier with continuously variable gain. The front panel FINE/ZERO control should be adjusted for zero dc output current (assuming the input source has no dc input component). With the values given in Figure 3-17, the external oscillator must have a voltage output of 1.5 volts peak in order to drive the power amplifier to its full output current capability. The impedance seen by this external voltage source will be approximately 1.7K.

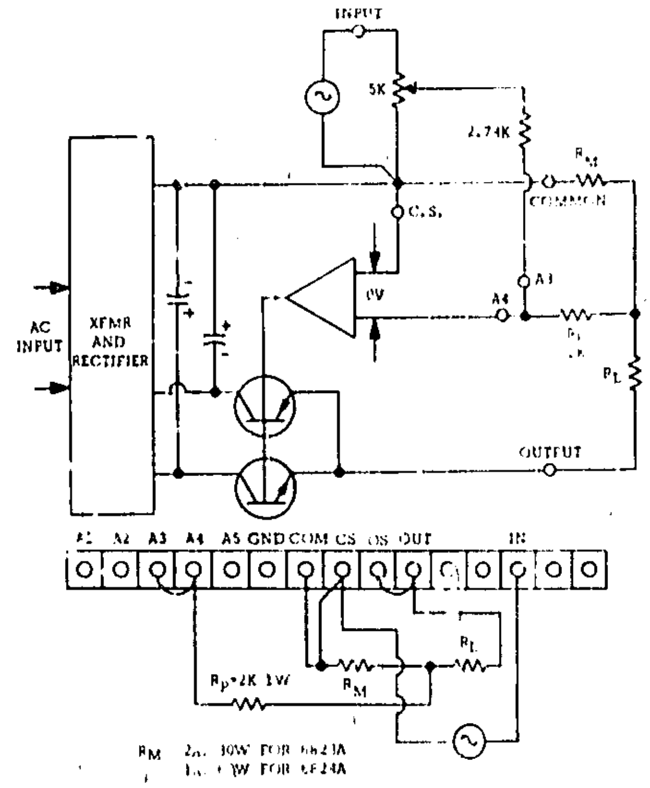


Figure 3-17. Standard Constant Current Amplifier

3-73 REMOTE PROGRAMMING, BIPOLAR OUTPUT

3-74 Figure 3-18 shows one method of controlling the output of the PS/A as a remote programmed Constant Current power supply. Switch S1 causes the output current to be either positive or negative. If it is desired to achieve only a positive or only a negative output current (unipolar output), then S1 must be eliminated. Terminal A4 is strapped directly to A2 for a positive output, or directly to A1 for a negative output.

3-75 The front panel FINE/ZERO control permits the output current to be adjusted to zero when Rp is set to zero, while the slope of the programming coefficent is adjusted by means of R_{38} (positive output) and R_{39} (negative output). Either of the switched resistance schemes of Figure 3-10 may be substituted for a variable Rp in this or any other Constant Current diagrams which follow. The advantage of the circuit of Figure 3-18 is that the output current is a <u>linear</u> function of the programming resistance; the disadvantage is that a switch must be used in order to accomplish polarity reversing.

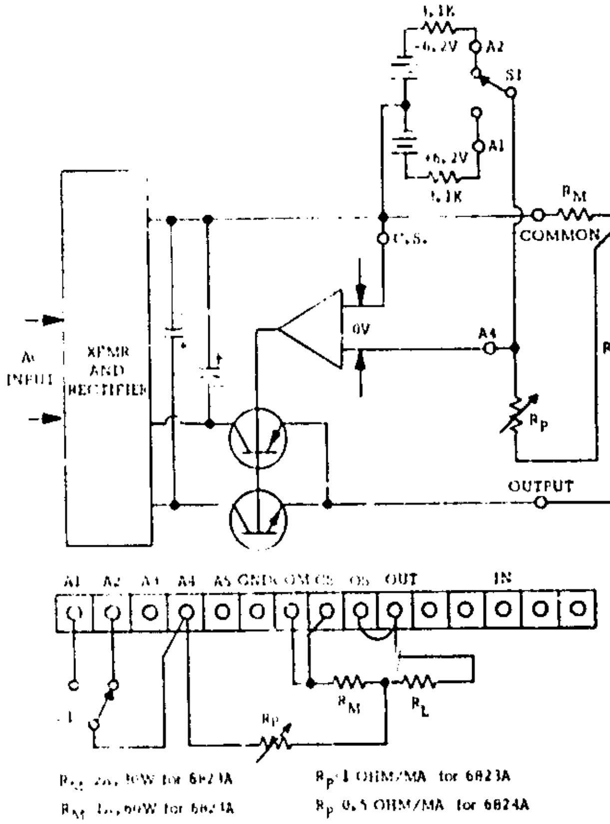


Figure 3-18. Remote Resistance Programming, Bipolar Output (CC)

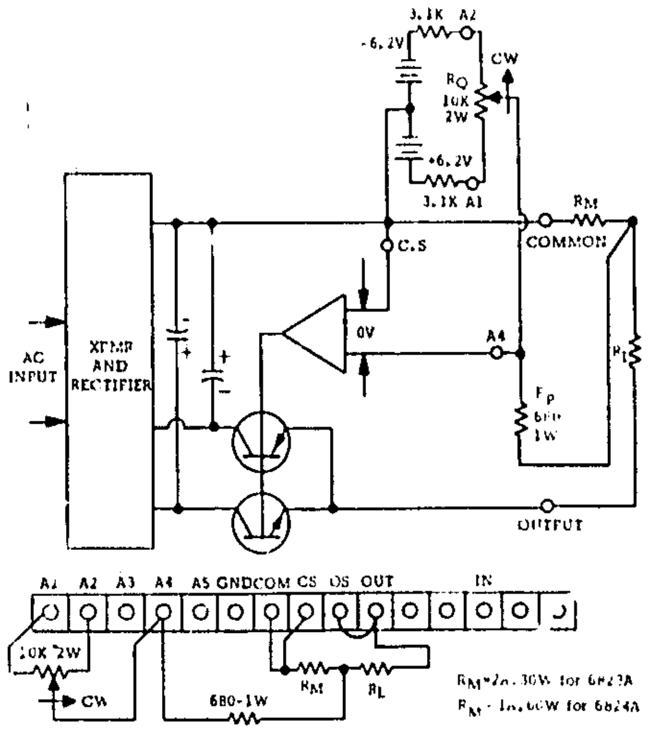


Figure 3-19. Switchless Bipolar Programming (CC)

3-76 SWITCHLESS BIPOLAR PROGRAMMING

3-77 Figure 3-19 shows the method of connecting the PS/A for Constant Current bipolar programming without the necessity for polarity switching. The 680 ohm resistor should be wire-wound with a temperature coefficient of less than 20 ppm/°C. Switched resistances can be substituted for resistor R_Q in Figure 3-19. The disadvantage of this mode lies in the non-linear (but accurately reproducible) programming characteristic.

3-78 CONSTANT CURRENT SUPPLY WITH SUPERIMPOSED AC OUTPUT

3-79 Figure 3-20 shows the method of adding an AC component on top of the adjustable DC output current. The dc level is controlled in the normal fashion from the front panel. The amplitude of the added ac component is determined by the value of R_Y, which, however, should not have a value less than the minimum load resistance which the external signal source is capable of driving without overloading or distorting.

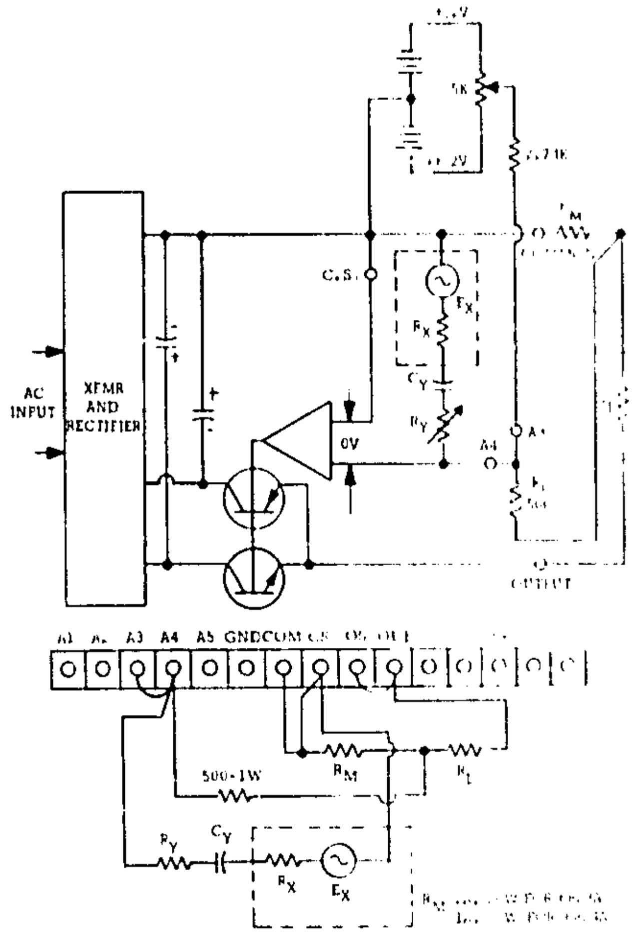


Figure 3-20. CC Power Supply With Superimposed AC Output

3-80 The peak voltage E_X which is necessary to achieve a peak output current equal to the maximum rating of the instrument, equals $(R_X + R_Y)/R_P$. The capacitor C_Y is added to block the DC current path through the oscillator. C_Y must be selected large enough to pass the lowest frequency of interest; the low frequency 3 db down point will be at

$$f = \frac{1}{2\pi (R_X + R_Y) C_Y}$$

where R_X is the internal (Thevenin equivalent) source resistance. Of course, capacitor C_Y is not employed if it is desired for the Constant Current output to respond to the dc component of the external signal source.

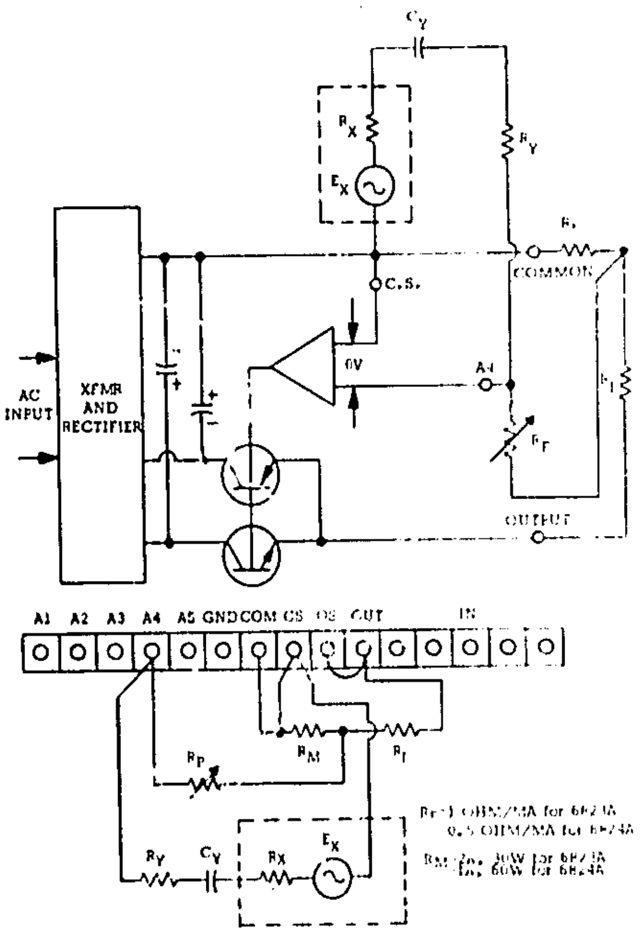


Figure 3-21. CC Amplifier With Linear Remote Gain Control

3-81 CONSTANT CURRENT AMPLIFIER WITH REMOTE GAIN CONTROL

3-82 Figure 3-21 shows the method of connecting an external voltage source with a PS/A to obtain Constant Current output with linear remote gain control. Using the recommended values for R_S, the output current is given by:

$$I_O = (E_X/R_M) \cdot R_P/(R_X + R_Y).$$

It is recommended that R_Y be selected so that at the peak input voltage E_X the current flowing through R_X, R_Y, and R_P is 2 MA. With this choice, R_P = 500 ohms results in an output current equal to the maximum rating of the instrument.

3-83 C_Y is chosen large enough to pass the lowest frequency of interest and is omitted if it is desired to have the output current responsive to the DC (as well as AC) component of the input voltage E_X.

3-84 Care should be taken that R_Y is chosen to be more than the minimum load resistance which the external signal source can feed without overload or distortion. However, R_Y should not be chosen too large, or the current flowing through R_P will be influenced by the current into the comparison amplifier. Thus it is undesirable to select R_Y so that the current flowing through it with full input signal is less than 1 MA.

3-85 Current Input. The combination of components E_X, R_X, and R_Y can always be replaced by a Constant Current source. If this is done, the current gain of the configuration of Figure 3-21 is:

$$\frac{I_{OUT}}{I_{IN}} = \frac{R_P}{R_M}$$

3-86 Two or More Inputs. If desired, the circuit of Figure 3-22 can be used to add the effect of two or more signals. All the equations given in this section hold true for each of the multiple inputs, with no interaction.

$$I_O = \frac{E_X}{R_M} \cdot \frac{R_P}{R_X + R_Y} + \frac{E_X'}{R_M} \cdot \frac{R_P}{R_X' + R_Y'} + \ldots$$

3-87 SERIES AND PARALLEL OPERATING MODES

3-88 The following paragraphs include methods for combining separate PS/A's in series and parallel combinations. These methods are employed whenever it is required to extend the voltage or current capability beyond that available from one instrument alone. In all of the following diagrams the strapping pattern and circuit configuration for slave units have been shown in complete detail. In several of the diagrams, however, the strapping pattern and circuit configuration have not been completed for the Master unit. This was done because the configuration chosen for the Master is determined by the manner in which it is desired for the ensemble of units to operate, and may be selected from any of the diagrams already given in this Section. Whether a combination acts as a power supply or amplifier, Constant Voltage or Constant Current source, locally or remotely controlled by resistance, voltage, or current, depends entirely on the connection mode selected for the Master Unit.

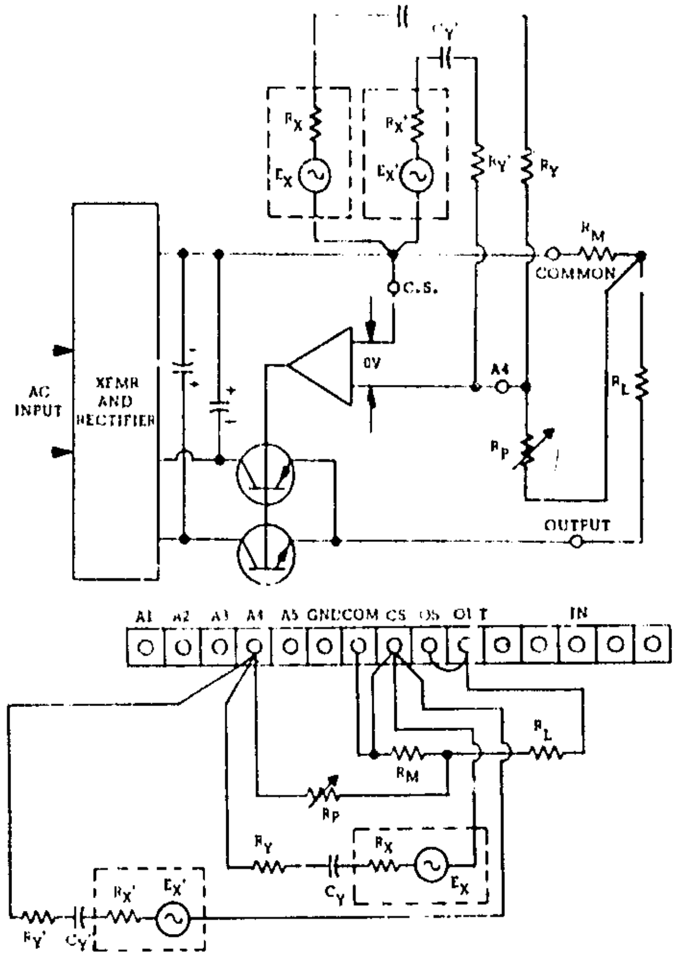


Figure 3-22. CC Amplifier With Two Inputs

3-89 Any PS/A instrument may be master or slave, depending only on the strapping pattern chosen. Units may be connected in series up to 300V off ground. They need not be the same model number, but should all be PS/A Series instruments. Similarly, units may be connected in parallel, without any limit, except that all instruments must be PS/A Series and employ an external sampling resistor which develops a 1 volt drop.

3-90 COORDINATED SERIES OPERATION

3-91 Auto-Series, Two Units, Single Ended Output. To increase the voltage output two units can be connected in Auto-Series as shown on Figure 3-23. The front panel switch position of the slave is not significant, but the front panel position and barrier strip wiring of the master unit depends upon the operating mode desired for the system of two power supplies, and should be selected from one of the previous alternatives.

3-92 For instantaneous equal voltage sharing, R_1 and R_2 must be equal. However, if it is desired for the slave to have a voltage, which although always proportional to the output of the master supply, is greater than or less than the output of the master supply, then R_2 should be selected according to the relation $E_S = E_M (R_2/R_1)$ where E_S and E_M are the output voltage of the Slave and Master instruments respectively.

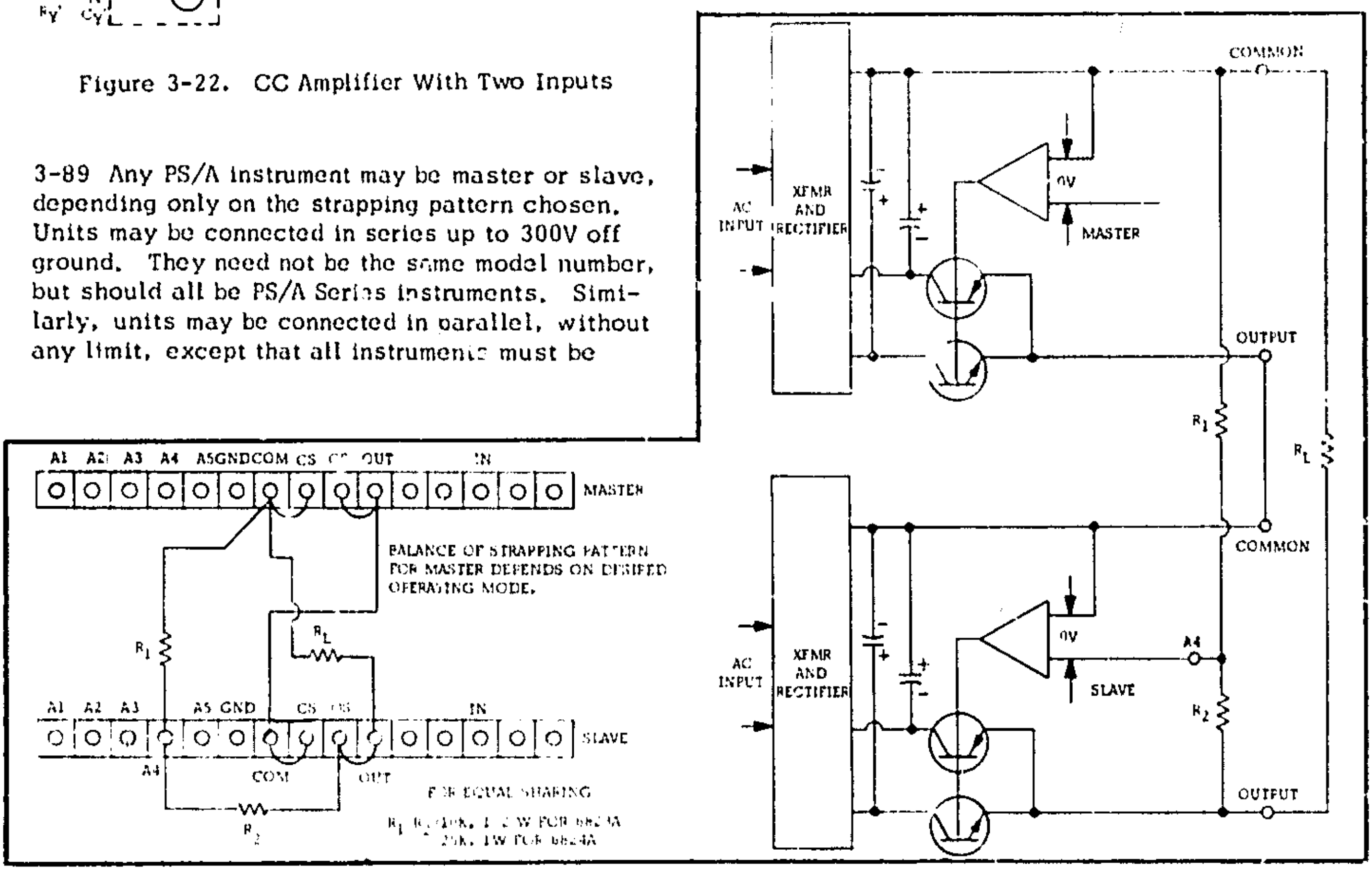


Figure 3-23. Auto-Series Operation, Two Units

3-93 Auto-Series, Three or More Units. The concept of the previous paragraphs is easily extended to three supplies as shown in Figure 3-24. If unequal voltage contributions are desired, the output of Slave #1 is given by $E_{S1} = E_M (R_2/R_1)$; for Slave #2, $E_{S2} = E_M (R_3/R_1)$.

3-94 The concept of Figure 3-24 is easily extended to series combinations involving more than three units by merely iterating that portion of the circuit configuration which is bounded by the two horizontal dotted lines.

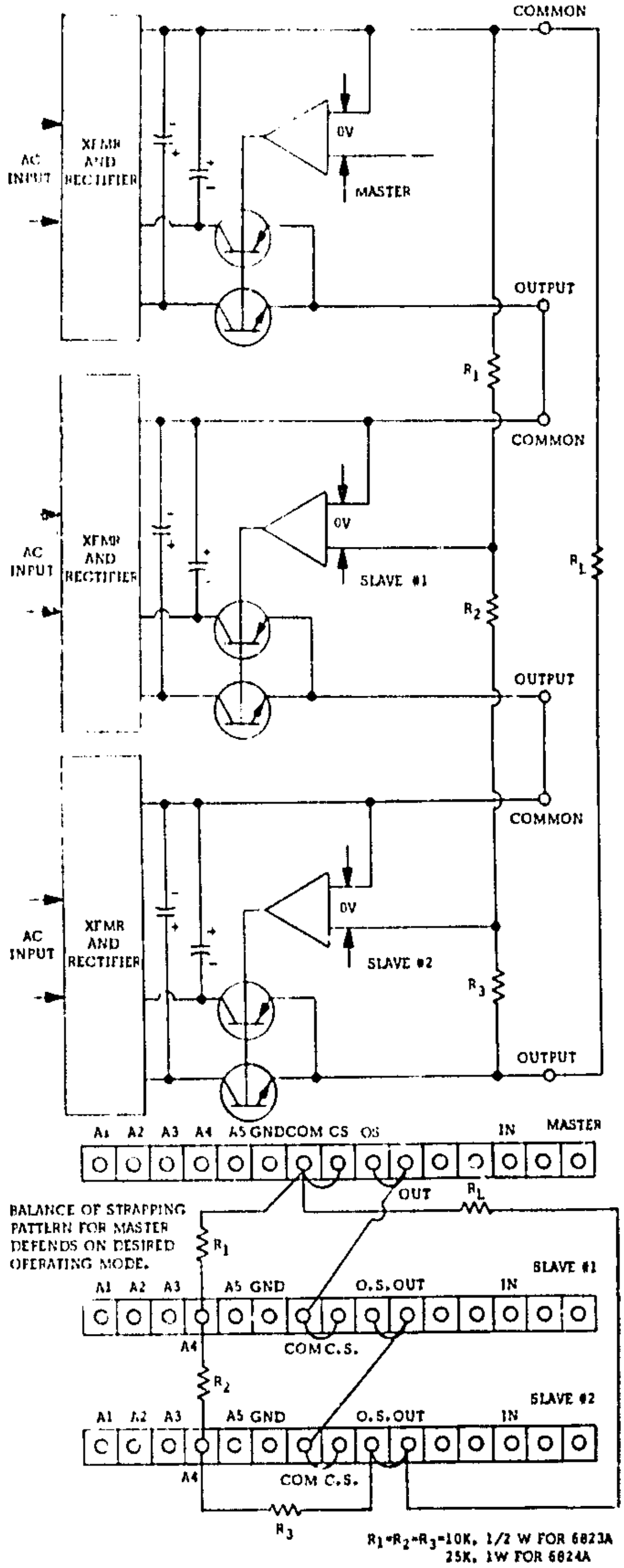


Figure 3-24. Auto-Series Operation, Two Units

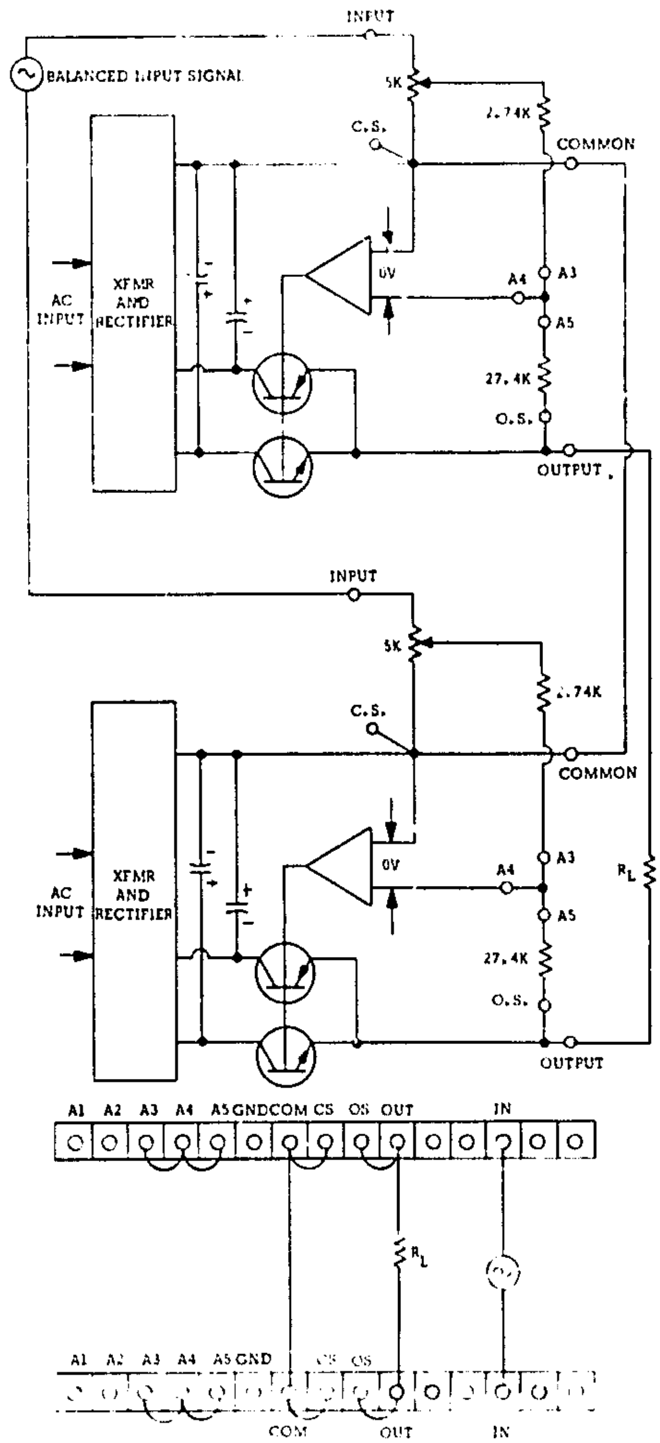


Figure 3-25. Balanced Input/Output Series Operation, Two Units

3-95 Series Operation, Balanced Output. The previous Auto-Series configurations are accomplished with single-ended input and single ended output having a common terminal. In some applications, however, it is necessary to employ an amplifier with input and output signals balanced about ground. Figure 3-25 shows the circuit configuration and strapping pattern for this mode of operation.

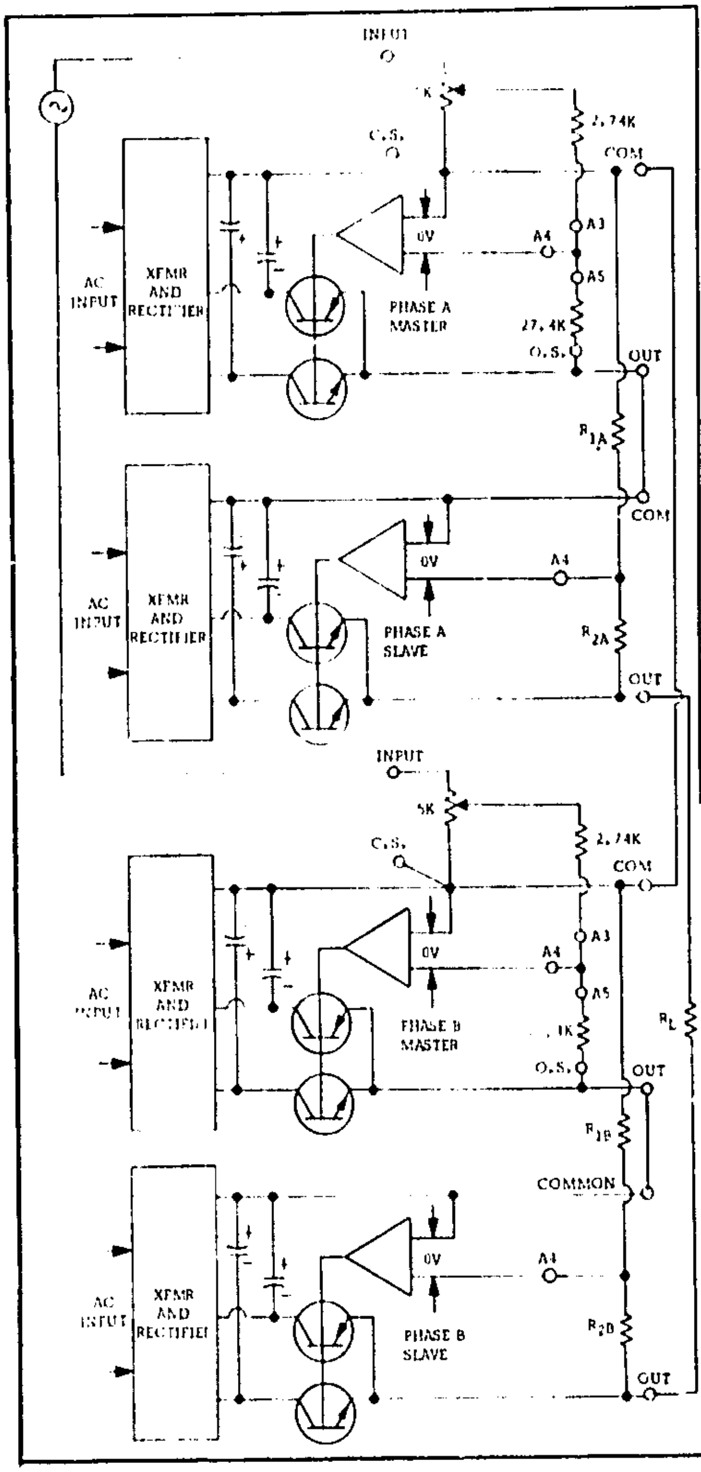
3-96 Since this mode is more likely to be employed as an amplifier rather than as a power supply, the diagram shows an oscillator input. The voltage input to this circuit must be at least 1/10th the desired voltage output; the input impedance seen by the oscillator is approximately 3.4K.

3-97 The balanced input concept can be extended to even higher voltages if voltage Slaves are added to each side. Figure 3-26 shows this configuration, which has an output voltage capability four times that of one unit alone, as well as a balanced input and a balanced output. The input oscillator must have a voltage capability of at least 1/20th of the output voltage desired, and faces an input impedance of 3.4K.

3-98 AUTO PARALLEL OPERATION

3-99 Constant Voltage Output. Figure 3-27 shows the correct method of connecting two PS/A's in parallel for increased output current in Constant Voltage operation. Although the terminal configuration has been completed for the Slave unit, the remainder of the connections to the Master unit are dependent upon desired operating mode. Thus the Master can be connected in any of the patterns shown in Section III, and the Auto-Parallel system will behave accordingly.

3-100 For equal current sharing, the leads from common to R_M and R_M to R_L should be short and have equal resistance for the two supplies. Greater current capability can be obtained by connecting more Slaves to the Master unit.



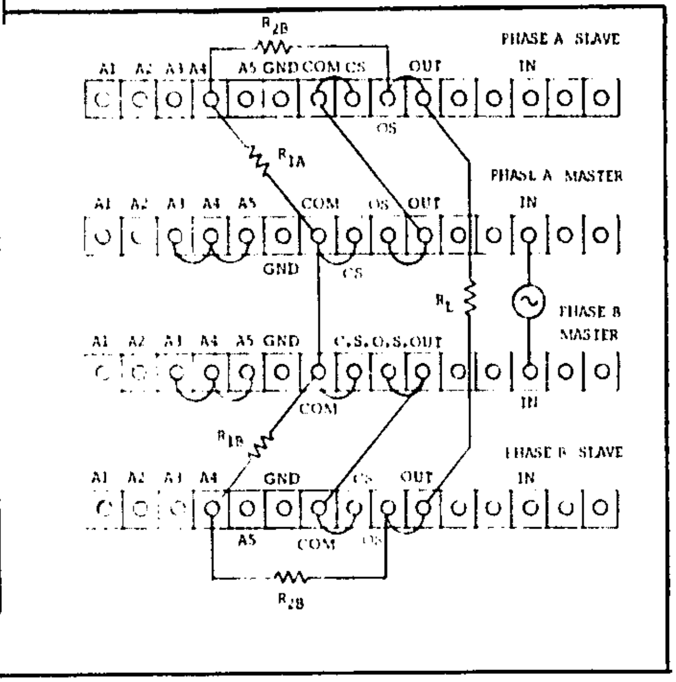


Figure 3-26. Balanced Input/Output Series Operation, Four Units

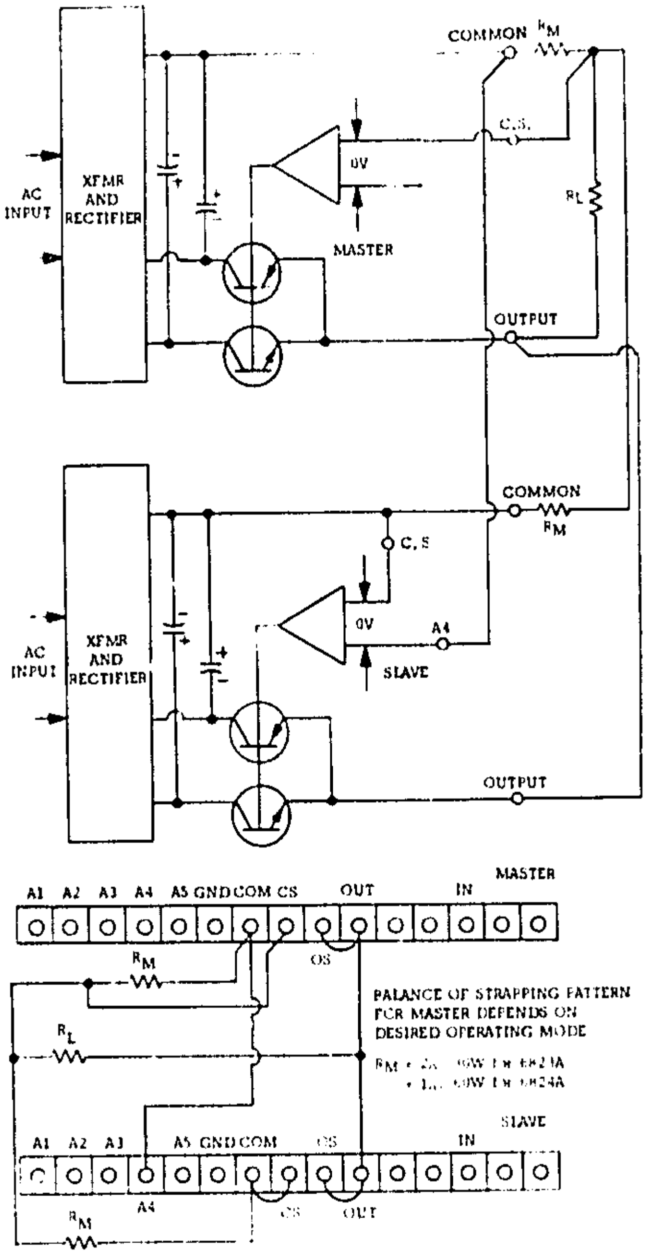


Figure 3-27. Auto-Parallel Operation, Constant Voltage Output

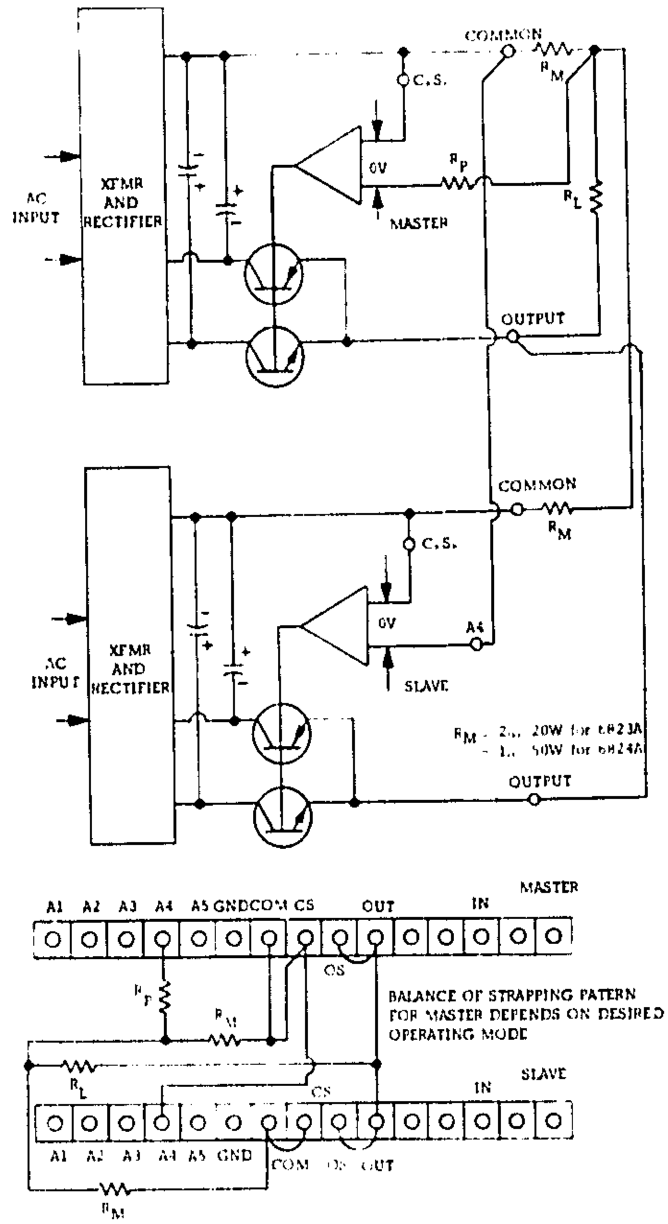


Figure 3-28. Auto-Parallel Operation, Constant Current Output

3-101 Constant Current Output. Figure 3-28 shows the correct method of connecting two supplies in Auto-Parallel for Constant Current output. The strapping configuration and circuit diagram for the master unit are not complete but can be wired in accordance with any of the diagrams given in Section III and the Auto-Parallel combination will behave accordingly. Still greater current output can be accomplished by adding any desired number of slaves to the master in the same way.

THEORY

SECTION IV
PRINCIPLES OF OPERATION

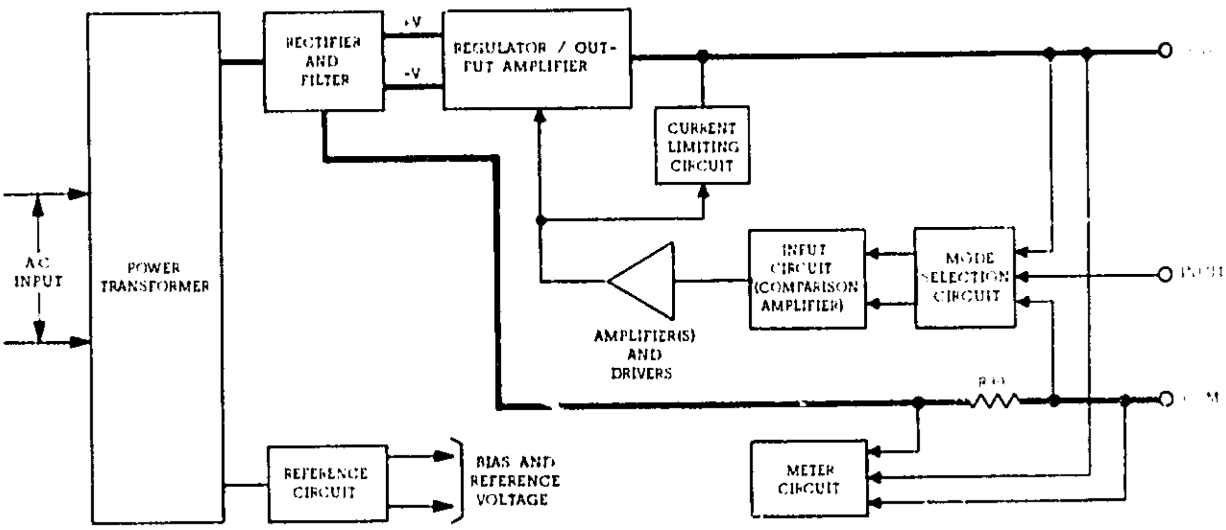


Figure 4-1. Overall Block Diagram

4-1 OVERALL BLOCK DIAGRAM DISCUSSION (Figure 4-1)

4-2 The Power Supply/Amplifier (PS/A) can be operated as either a power supply or a power amplifier. The operating mode is determined by the mode selection circuit which couples to the input circuit; either the voltage across the output terminals (during power supply operation) or the voltage across the input terminals (during amplifier operation).

4-3 POWER SUPPLY OPERATION

4-4 During power supply operation, the PS/A functions as a well-regulated dc power supply capable of furnishing a bi-polar, Constant Voltage output. Constant Current operation can also be achieved by connecting an external current sampling resistor to the unit.

4-5 The ac line voltage is reduced to the proper level by the power transformer and coupled to the rectifier and filter. The rectifier-filter converts the ac input to raw dc which is fed to the regulator/output amplifier circuit in both positive and negative form. The regulator/output amplifier acts as a series regulator during power supply operation. Its conduction is altered in accordance with the feedback control signals received from the driver amplifiers, thus maintaining the output voltage (or current) constant. The feedback control signals also determine the polarity of the output voltage. For positive power supply output voltages the regulator circuit receives a positive input and for negative output voltages it receives a negative input. Hence, the dc output voltage can be continuously adjusted from its maximum rated positive value to an equal negative value.

4-6 The current limiting circuit monitors the output current passing through the regulator. If this current exceeds a certain preset limit, the limiting circuit conducts, shunting input current away from the regulator and thus keeping the output current constant.

4-7 The input circuit serves as the first "link" in the feedback circuit. It detects any changes in the output voltage and sends a feedback control signal to the series regulator via the amplifier drivers. The feedback signal is of the correct phase and amplitude to counteract the change in output voltage. Notice that the supply can also be used as a Constant Current source as outlined in Section III of this manual. Under these conditions, the input circuit monitors the voltage dropped across an externally connected current sampling resistor and, in this manner develops the feedback error signals necessary to maintain the output current constant.

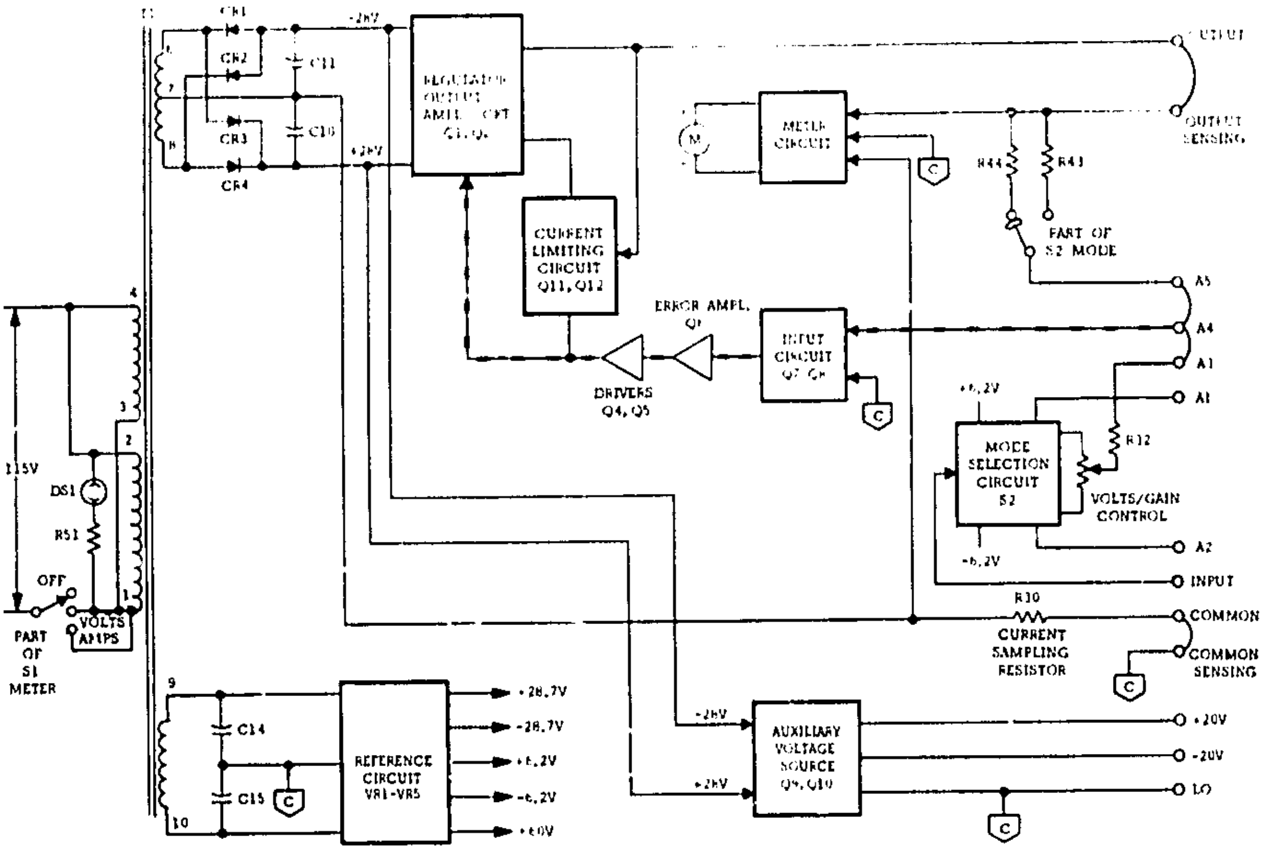


Figure 4-2. Simplified Schematic

4-8 The reference circuit provides stable reference voltages which are used throughout the unit for biasing and comparison purposes. The meter circuit provides indications of dc output voltage or current. When measuring voltage it is connected across the output of the supply; when measuring current it is connected across an internal current sampling resistor, R30.

4-9 AMPLIFIER OPERATION

4-10 During amplifier operation, the unit acts as a power amplifier with a single-ended, push-pull output stage. It furnishes either a Constant Voltage output or a Constant Current output (with the addition of an external current sampling resistor). It is capable of amplifying both ac and dc input signals over a bandwidth of dc to 20 kHz.

4-11 Input signals are received from the external source via the input and common terminals. The input circuit and amplifier-drivers amplify the signal and forward it to the regulator/output amplifier circuit. This circuit functions as a push-pull output amplifier during amplifier operation, although note that no internal connections are necessary in the regulator/output amplifier circuit in order to accomplish this.

4-12 The current limiting circuit is operable in the amplifier mode and serves to protect both the amplifier and the load by preventing the output current from exceeding the preset current limit.

4-13 In a manner similar to that used during power supply operation, the input circuit generates the error signals necessary to keep the output voltage (or current) constant despite variations in the load or line circuits. The meter circuit for Model 6824A units is capable of indicating ac output voltage during amplifier operation, while Model 6823A meter circuits can measure dc output voltage only.

4-14 SIMPLIFIED SCHEMATIC

4-15 A simplified schematic of the PS/A is shown in Figure 4-2. It shows the internal sources of bias and reference voltages and their nominal magnitudes with an input of 115Vac and under full load. METER switch S1 turns on the unit by applying input power to the primary circuit of T1 in both the volts and AMPS positions. Another portion of METER switch S1, included in the meter circuit block on Figure 4-2, permits the meter to read either output voltage or current. Rectifier diodes CR1 through CR4, and filter capacitors C10 and C11 provide

+28Vdc and -28Vdc to the regulator output amplifier circuit. These voltages are also fed to the auxiliary voltage source circuit which, in turn, provides regulated dc voltages (±20Vdc) for possible external use.

4-16 MODE switch S2, in the mode selection circuit, connects the VOLTS/GAIN potentiometer between a bi-polar reference source (+6.2V and -6.2V) during power supply operation, or across the external input signal path during amplifier operation. Hence, the position of the VOLTS/GAIN potentiometer determines the polarity and magnitude of the output voltage in the power supply mode or the gain of the PS/A in the amplifier mode.

4-17 Notice that the PS/A does not have the large output capacitor connected across most power supplies to insure feedback loop stability. This capacitor has been removed to ease the bandwidth limitations during amplifier operation. Removal of the output capacitor has the additional advantage of greatly enhancing the programming speed during power supply operation. Alternate methods of insuring feedback loop stability are employed throughout the PS/A feedback circuit to offset the absence of this capacitor.

4-18 DETAILED CIRCUIT ANALYSIS (See schematic at rear)

4-19 INPUT CIRCUIT

4-20 The input circuit consists basically of a differential amplifier stage (Q7 and Q8), and the FINE/ZERO and VOLTS/GAIN controls (R52A and R52B). Note that for simplicity's sake, R52A has been included in the mode selection circuit on the schematic.

4-21 The input circuit controls the conduction of the series regulator/output amplifier transistors. To accomplish this, the circuit continuously compares a fraction of the output voltage (or current) with a fixed reference voltage and, if a difference exists, produces an "error" voltage whose amplitude and phase is proportional to the difference. The "error" output is fed back to the regulator/output amplifier, via the error and driver amplifiers. The feedback voltage alters the conduction of the regulator/output amplifier transistors which, in turn, alter the output voltage (or current) so that the difference between the two differential amplifier input voltages is reduced to zero. The above action not only maintains a constant output regardless of line or load variations; but establishes output levels in accordance with the setting of the VOLTS/GAIN control.

4-22 Stage Q7 of the differential amplifier is connected to a voltage divider consisting of R40, R52B, R47, and R48. The FINE/ZERO control, R52B, permits the bias at the base of Q7 to be adjusted slightly above or below the common sensing (C) point. During power supply operation the FINE/ZERO control provides a fine adjustment of the dc output voltage or current and during amplifier operation it provides a dc "offset" adjustment of approximately 1% of the maximum rated output. Hence, the average value of an ac output signal can be adjusted exactly to zero with this control.

4-23 Stage Q8 is connected to the voltage (or current) summing point (A4) at the junction of the VOLTS/GAIN control and resistor R44 or R43. The potential at the summing point will instantaneously change if the output voltage/current attempts to change or if the voltage that is picked off by R52A changes. Output variations affect the voltage dropped across R43 or R44 thus changing the summing point potential. Similarly, moving the VOLTS/GAIN control arm affects the summing point potential. During power supply operation, this control is connected across a bi-polar reference source. Moving the control toward the positive end of the potentiometer causes the summing point to go positive resulting in a more negative output. Conversely, moving the control toward the negative end results in a more positive output. During amplifier operation the external input signal is applied across R52A and moving the control arm varies the amount of signal that is picked off.

4-24 Summing point variations are felt at the base of the Q8 which varies its conduction in accordance with the polarity and magnitude of the change at the summing point. The change in Q8's conduction also varies the conduction of Q7 due to the coupling effects of common emitter resistor, R29. The error voltage is taken from the collector of Q7 and ultimately alters the conduction of the regulator/amplifier transistors.

4-25 Feedback networks C6, R25, and C5, R46 help stabilize the feedback loop. Diodes CR27 and CR28 form a limiting network which prevent excessive voltage excursions from over-driving stage Q8. Resistor R45 in series with the base of Q8 is a current limiting resistor.

4-26 MODE SELECTION CIRCUIT

4-27 The mode selection circuit consists basically of MODE switch S2 which determines the operating mode of the instrument. As mentioned previously, S2 connects the VOLTS/GAIN control between a bi-polar reference source in the SUPPLY position and across the input signal path in the AMPLIFIER position. In the AMPLIFIER position S2 also connects a load resistor (R57) between the bi-polar reference voltages to prevent loading down the reference circuit.

4-28 ERROR AND DRIVER AMPLIFIERS

4-29 The error and driver amplifiers amplify the error signal from the input circuit to a level sufficient to drive the regulator/amplifier transistors. Stage Q6 contains a stabilization network, C7 and R24, which provides for roll off in the loop gain. Diode CR11 clamps the emitter of Q6 to a stable reference voltage, +28.7V. Emitter follower Q4 drives both regulator/amplifier transistors Q1 and Q2.

4-30 REGULATOR/OUTPUT AMPLIFIER CIRCUIT

4-31 During power supply operation, transistors Q1 and Q2 serve as series control elements in the positive and negative output lines, respectively. The conduction of the series transistors is controlled by the feedback voltage from Q4. Note that when the feedback voltage is negative, PNP transistor Q2 is conducting and NPN transistor Q1 is cut-off. Under these conditions, the supply furnishes a negative output voltage. The reverse is true when the feedback voltage if of positive polarity. Transistor Q3 furnishes a constant bias current to the bases of Q1 and Q2. At zero volts output, both Q1 and Q2 are conducting slightly because of the base current provided by Q3. Diodes CR18 and CR19 provide the voltage drop necessary to forward bias both transistors simultaneously. This effect eliminates any "dead spots" when the output voltage is programmed away from zero. Note, however, that as soon as the output voltage is driven away from zero, one transistor remains conducting while the other is cutoff.

4-32 During amplifier operation, Q1 and Q2 serve as a single-ended, push-pull, output amplifier. Although the schematic at the rear of the manual shows Q1 and Q2 drawn as a conventional series regulator, a closer inspection will reveal that the circuit could be redrawn as a push-pull amplifier without changing any of the connections. Transistors Q1 and Q2 are biased for Class AB operation and connected in a complementary configuration, as described in the previous paragraph, thus obviating the need for center-tapped input and output transformers.

4-33 CURRENT LIMITING CIRCUIT

4-34 The current limiting circuit consists of transistors Q11 and Q12 and associated resistors. These transistors keep the output current from exceeding the current limit established by the setting of potentiometers R5 and R6. PNP transistor Q11 limits the current in the negative line and NPN transistor Q12 limits the current in the positive line. Under increased current demands, the current through Q2 increases, increasing the voltage drop across R2 and R6 and driving the base of Q11 in a negative direction. The conduction of Q11 limits the base current of Q2 and, hence, the output current. Operation of current limiting transistor Q12 is similar; except that the base current of Q1 is limited further back in the feedback loop at the input of Q4.

4-35 REFERENCE CIRCUIT

4-36 The reference circuit is an auxiliary supply which provides stable reference voltages used throughout the instrument for biasing and comparison purposes. The bi-polar reference voltages are developed across temperature compensated Zener diodes VR1 through VR5. The reference voltages are all derived from smoothed positive and negative dc obtained from full wave rectifier CR5, CR6 and CR7, CR8 and filter capacitors C12 and C13.

4-37 METER CIRCUIT

4-38 The meter circuit provides continuous indications of output voltage or current on a single meter. The meter can be used as a voltmeter or ammeter depending upon the position of METER switch S1. With S1 in the VOLTS position the meter is connected in series with R31 and R33 across the output of the supply. Resistor R31 permits voltage calibration of the meter to compensate for slight resistance variations.

4-39 With S2 in the AMPS position, the meter is connected across current sampling resistor R30, whose voltage drops varies in proportion to the output current. Current calibrate potentiometer, R35 is adjusted for full scale deflection in the current range.

4-40 The meter movement used in this instrument, can withstand a current overload of many times the maximum rated output without damage.

4-41 AUXILIARY VOLTAGE SOURCE

4-42 This circuit provides fixed, moderately regulated, ±20 Vdc outputs that can be used as desired. Transistors Q9 and Q10 are series regulators which vary their conduction to maintain the output voltages constant. The bases of the series regulators are held at fixed voltages while the emitter voltages are allowed to vary instantaneously with output voltage changes. Varying the emitter voltages alters the conduction of Q9 and Q10 in the direction and by the amount necessary to keep the output voltage constant.

MAINTENANCE

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 Upon receipt of this instrument, the performance check (Paragraph 5-10) should be made. This check is suitable for incoming inspection. If a fault is detected in the unit while making the performance check or during normal operation, proceed to the troubleshooting procedures (Paragraph 5-24). After troubleshooting and repair (Paragraph 5-34), perform any necessary adjustments and calibrations (Paragraph 5-36). Before returning the PS/A to normal operation, repeat the performance check to ensure that the fault has been properly corrected and that no other faults exist. Before doing any maintenance checks, turn-on power supply, allow a half-hour warm-up, and read the general information regarding measurement techniques (Paragraph 5-3).

5-3 GENERAL MEASUREMENT TECHNIQUES

5-4 The measuring device must be connected across the sensing leads of the unit or as close to the output terminals as possible when measuring the output impedance, transient response, regulation, or ripple of the power supply in order to achieve valid measurements. A measurement made across the load includes the impedance of the leads to the load and such lead lengths can easily have an impedance several orders of magnitude greater than the supply impedance, thus invalidating the measurement.

5-5 The monitoring device should be connected to the OS and CS terminals or as shown in Figure 5-1. The performance characteristics should never be measured at the front terminals if the load is connected across the rear terminals. Note that when measurements are made at the front terminals, the monitoring leads are connected at A, not B; as shown in Figure 5-1. Failure to connect the measuring device at A will result in a measurement that includes the resistance of the leads between the output terminals and the point of connection.

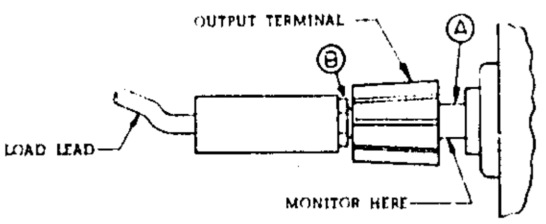


Figure 5-1. Front Panel Terminal Connections

5-6 For output current measurements, the current sampling resistor should be a four-terminal resistor. The four terminals are connected as shown in Figure 3-15. In addition, the resistor should be of the low noise, low temperature coefficient (20ppm/°C or less) type and should be used at no more than 5% of its rated power so that its temperature rise will be minimized.

5-7 When using an oscilloscope, ground the common terminal of the PS/A and then ground the case of the oscilloscope to this same point. Make certain that the case is not also grounded by some other means (such as the power line). Connect both oscilloscope input leads to the PS/A ground terminal and check that the oscilloscope is not exhibiting a ripple or transient due to ground loops, pick-up, or other means.

5-8 TEST EQUIPMENT REQUIRED

5-9 Table 5-1 lists the test equipment required to perform the various procedures described in this Section.

Table 5-1. Test Equipment Required

Type	Required Characteristics	Use	Recommended Model
Differential Voltmeter	Sensitivity: 1 mv full scale (min.). Input impedance: 10 megohms (min.).	Measure DC voltages; calibration procedures	hp 3420 (See Note)
Variable Voltage Transformer	Range: 90-130 volts. Equipped with voltmeter accurate within 1 volt.	Vary AC input	-------
AC Voltmeter	Accuracy: 2%. Sensitivity: 1 mv full scale deflection (min.).	Measure AC voltages and ripple.	hp 403 B
Oscilloscope	Sensitivity: 10 μv/cm. Differential input.	Peak-to-peak measurements. Waveform displays.	hp 140 A plus 1400 A plug in.
Oscillator	Range: 5 Hz to 600KHz Accuracy: 2%	Impedance Checks, amplifier input source	hp 200 CD
Square Wave Generator	Rise time: 0.02 μsec Frequency: 1 Hz to 1 MHz	Measure programming speed	hp 211 A
Repetitive Load Switch	Rate: 60-400 Hz, 2μsec rise and fall time.	Measure transient response	See Figure 5-5
Resistor	Value: See Paragraph 5-13 and Figure 5-3, ±5%, 75 watts	Load Resistor	-------
Resistor	Value: See Figure 5-3. 1%, 30 watts (6823A) 60 watts (6824A) 20ppm, 4-Terminal.	Current sampling	-------
Resistor	1 KΩ ±1%, 2 watt non-inductive	Measure impedance	-------
Resistor	100 ohms, ±5%, 10 watt	Measure impedance	-------
Capacitor	500μf, 50 wvdc	Measure impedance	-------

NOTE

A satisfactory substitute for a differential voltmeter is to arrange a reference voltage source and null detector as shown in Figure 5-2. The reference voltage source is adjusted so that the voltage difference between the supply being measured and the reference voltage will have the required resolution for the measurement being made. The voltage difference will be a function of the null detector that is used. Examples of satisfactory null detectors are: hp 419A null detector, a DC coupled oscilloscope utilizing differential input, or a 50 mv meter movement with a 100 division scale. For the latter, a 2 mv change in voltage will result in a meter deflection of four divisions.

CAUTION

Care must be exercised when using an electronic null detector in which one input terminal is grounded to avoid ground loops and circulating currents.

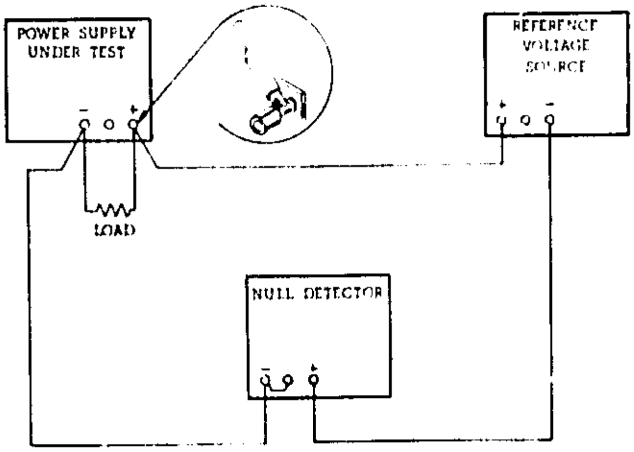


Figure 5-2. Differential Volt...ter Substitute, Test Setup

5-10 PERFORMANCE TEST

5-11 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated either to check the operation of the instrument after repairs or for periodic maintenance tests. The tests are performed using a 115-VAC 60 Hz, single phase input power source. They test the performance of the unit both as a power supply and as a power amplifier. If the correct result is not obtained for a particular check, do not adjust any controls; proceed to troubleshooting (Paragraph 5-24).

5-12 POWER SUPPLY TESTS

5-13 Rated Output and Meter Accuracy. To check the output voltage, proceed as follows:

a. Connect 40 ohm load resistor (50 ohms for Model 6824A) across rear output terminals of supply.

b. Connect differential voltmeter across OS and CS terminals of supply observing correct polarity.

c. Set METER switch to VOLTS and MODE switch to SUPPLY.

d. Adjust VOLTS/GAIN control clockwise (cw) until front panel meter indicates exactly the maximum rated positive output voltage.

e. Differential voltmeter should indicate maximum rated positive output voltage within ±2%.

f. Adjust VOLTS/GAIN control in ccw direction until front panel meter reads maximum rated negative output voltage.

g. Reverse position of input polarity switch on differential voltmeter. Voltmeter should indicate maximum rated negative output voltage within ±2%.

5-14 To check the output current, proceed as follows:

a. Connect test setup shown in Figure 5-3.

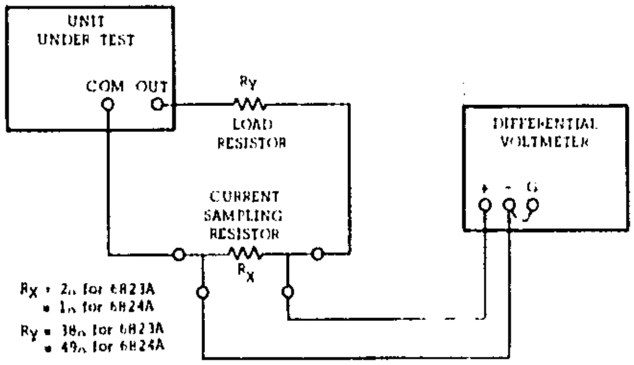


Figure 5-3. Output Current, Test Setup

b. Set METER switch to AMPS.

c. Turn on supply and adjust VOLTS/GAIN control cw until front panel meter indicates exactly maximum rated positive current.

d. Differential voltmeter should read 1±0.02 Vdc.

e. Reverse polarity switch on differential voltmeter and adjust VOLTS/GAIN control ccw for maximum rated negative current.

f. Differential voltmeter should again read 1±0.02 Vdc.

5-15 Load Regulation. To check the Constant Voltage load regulation, proceed as follows:

a. Connect test setup as shown in Figure 5-4.

b. Set METER switch to VOLTS.

c. Turn on supply and adjust VOLTS/GAIN control cw until front panel meter indicates maximum rated positive output voltage.

d. Read and record voltage indicated on differential voltmeter.

e. Disconnect load resistor.

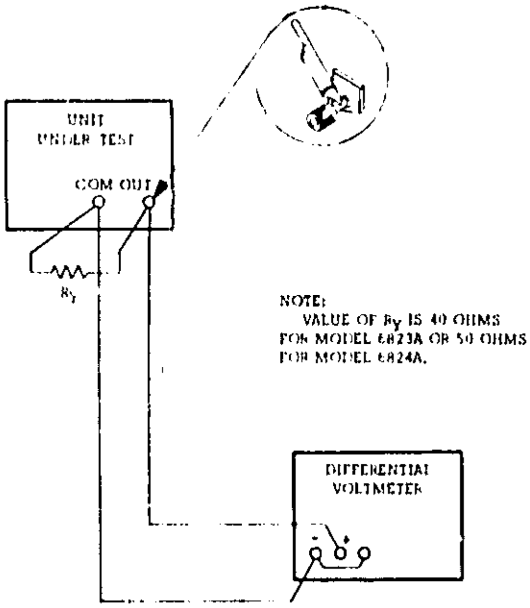


Figure 5-4. Load Regulation, Test Setup

f. Reading on differential voltmeter should not vary from reading recorded in step d by more than 9 mVdc for Model 6823A or 15 mVdc for Model 6824A.

g. Set input polarity switch to appropriate position. Rotate VOLTS/GAIN control ccw and repeat steps c through f for maximum rated negative output voltage.

5-16 Line Regulation. To check the Constant Voltage line regulation, proceed as follows:

a. Connect variable auto transformer between input power source and PS/A power input.

b. Connect test setup shown in Figure 5-4.

c. Adjust variable auto transformer for 105 or 210 Vac input.

d. Turn on supply and rotate VOLTS/GAIN control cw until front panel meter indicates exactly the maximum rated positive output voltage.

e. Read and record voltage indicated on differential voltmeter.

f. Adjust variable auto transformer for 115 or 250 Vac input.

g. Reading on differential voltmeter should not vary from reading recorded in step e by more than 9 mvdc for Model 6823A units or 15 mvdc for Model 6824A units.

h. Rotate VOLTS/GAIN control ccw to obtain maximum negative voltage and repeat steps d through g.

5-17 Ripple and Noise. To check ripple and noise, proceed as follows:

a. Retain test setup used for previous line regulation test except connect AC voltmeter (hp 403B) across output terminals instead of differential voltmeter.

b. Adjust variable auto transformer for 125 Vac input.

c. Turn on supply and adjust VOLTS/GAIN control cw until front panel meter indicates exactly the maximum rated positive output voltage.

d. AC voltmeter should read less than 2 mV rms (Model 6823A) or 10 mV rms (Model 6824A).

e. Reverse polarity of input to ac voltmeter and repeat steps c and d for maximum rated negative output voltage.

5-18 Transient Recovery Time. To check the transient recovery time of the supply, proceed as follows:

a. Connect test setup shown in Figure 5-5.

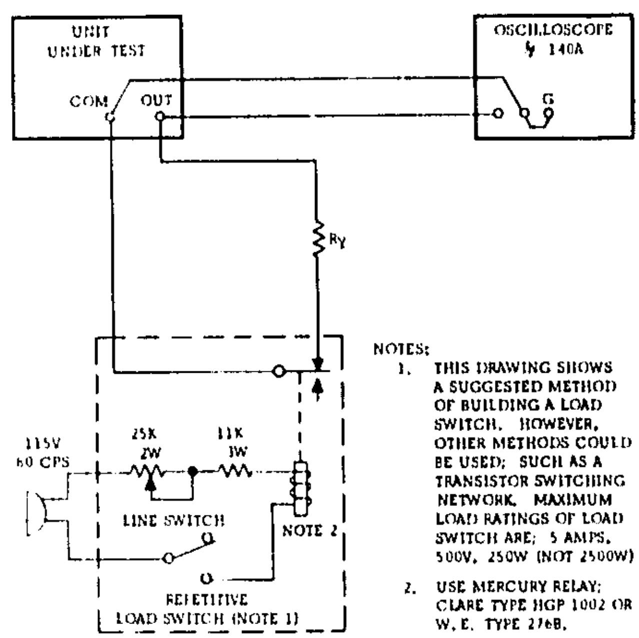


Figure 5-5. Transient Response, Test Setup

b. Rotate VOLTS/GAIN control cw to obtain maximum rated positive output.

c. Close line switch on repetitive load switch setup.

d. Adjust 25K potentiometer until a stable display is obtained on oscilloscope. Waveform should be within the tolerances shown in Figure 5-6 (output should return to within 5 mv of original value in less than 100 microseconds).

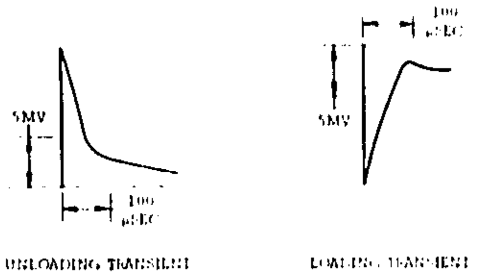


Figure 5-6. Transient Response Waveforms

e. Reverse input connections to oscilloscope and repeat steps c and d for maximum rated negative output.

5-19 Programming Speed. To check the unit's programming speed, a square wave is applied to the unit and it is operated in the amplifier mode. This has the same effect as rapidly programming the unit, up and down, in the power supply mode. To make this test, proceed as follows:

a. Connect test setup shown in Figure 5-7.

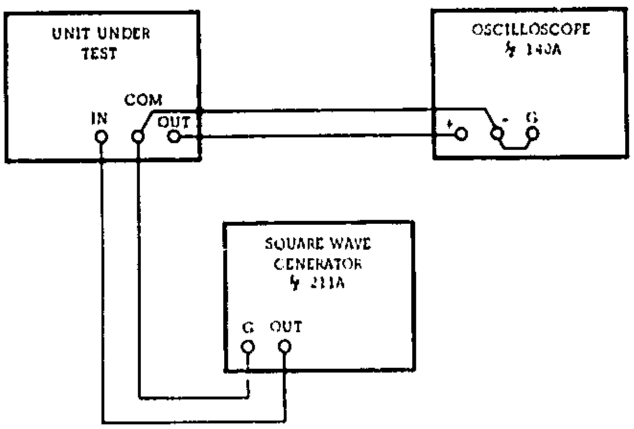


Figure 5-7. Programming Speed, Test Setup

b. Set MODE switch to AMPLIFIER and turn on unit.

c. Rotate VOLTS/GAIN control fully clockwise.

d. On pulse generator, set input frequency to about 2 KHz and adjust amplitude to obtain maximum rated peak-to-peak output signal on oscilloscope (-20V to +20V on Model 6823A and -50V to +50V on Model 6824A).

e. Adjust oscilloscope to observe rise time of one square wave. The wave shape should be within the tolerances shown on Figure 5-8 (output should change from maximum rated negative value to maximum rated positive value in less than 50 μsec).

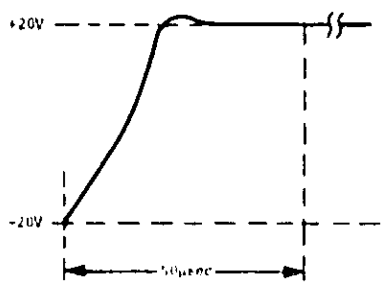


Figure 5-8. Typical Programming Speed Waveforms

f. Check the fall time of one square wave. It should be almost identical to the rise time except for inversion.

5-20 Output Impedance. To check the output impedance, proceed as follows:

a. Connect test setup shown in Figure 5-9.

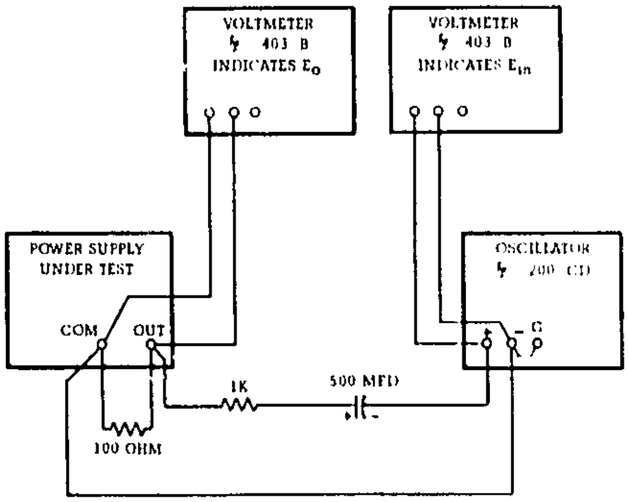


Figure 5-9. Output Impedance, Test Setup

b. Turn on supply and adjust VOLTS/GAIN control until front panel meter reads +10 volts (+20 volts for Model 6824A).

c. Set AMPLITUDE control on Oscillator to 10 volts (E_{in}), and FREQUENCY control to 100Hz.

d. Record voltage across output terminals of the power supply (E_o) as indicated on AC voltmeter.

e. Calculate the output impedance by the following formula.

$$Z_{out} = \frac{E_o R}{E_{in} - E_o}$$

E_o = rms voltage across power supply output terminals.
R = 1000
E_{in} = 10 volts

f. The output impedance (Z_{out}) should be less than 0.03 ohm.

g. Using formula of step e calculate output impedance at frequencies of 500Hz and 100KHz. Values should be less than 0.3 ohm and 3.0 ohms, respectively.

5-21 AMPLIFIER TESTS

5-22 Gain and Frequency Response. To check the gain and frequency response of the amplifier, proceed as follows:

a. Connect test setup shown in Figure 5-10.

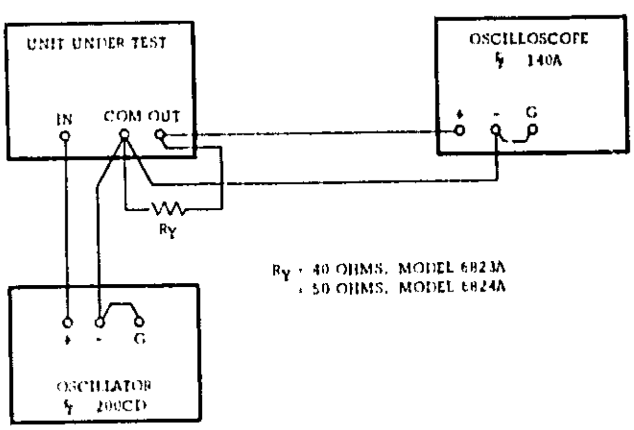


Figure 5-10. Gain and Frequency Response, Test Setup

b. Set MODE switch to AMPLIFIER.

c. Set oscillator frequency at 2KHz and output at 4 Vac, peak-to-peak (Model 6823A) or 10 Vac, peak-to-peak (Model 6824A).

d. Adjust VOLTS/GAIN control on amplifier to obtain 40 volt peak-to-peak (Model 6823A) or 100 volt peak-to-peak (Model 6824A) reading on oscilloscope. Reading should be within ±2% tolerance.

e. Adjust oscillator frequency to 20 KHz while maintaining same oscillator output voltage.

f. Waveform on oscilloscope should not be less than 29 volts peak-to-peak (Model 6823A) or 71 volts peak-to-peak (Model 6824A).

5-23 AC Meter Accuracy (Model 6824A Only). The front panel meter on Model 6824A units is capable of measuring ac output voltages. To check its accuracy, proceed as follows:

a. Retain test setup of Figure 5-10.

b. Repeat steps b through d of Paragraph 5-22.

c. METER switch to AC VOLTS position.

d. Front panel meter should indicate rms value of peak output voltage indicated on oscilloscope (E_o pk. x 0.707 = E_o rms).

5-24 TROUBLESHOOTING

5-25 Components within Hewlett-Packard instruments are conservatively operated to provide maximum reliability. In spite of this, parts within a unit may fail. Usually the instrument must be immediately repaired with a minimum of "down time" and a systematic approach as outlined in succeeding paragraphs can greatly simplify and speed up the repair.

5-26 TROUBLE ANALYSIS

5-27 General. Before attempting to trouble shoot this instrument, ensure that the fault is with the instrument and not with an associated circuit. The performance test (Paragraph 5-10) enables this to be determined without having to remove the instrument from the cabinet.

5-28 Once it is determined that the PS/A is at fault, check for obvious troubles such as an open fuse, a defective power cable, or an input power failure. Next, remove the top and bottom covers (each held by four retaining screws) and inspect for open connections, charred components, etc. If the trouble source cannot be detected by visual inspection, follow the detailed procedure outlined in succeeding paragraphs. Once the defective component has been located (by means of visual inspection or trouble analysis) correct it and reconduct the performance test. If a component is replaced, refer to the repair and replacement and adjustment and calibration paragraphs in this section.

5-29 A good understanding of the principles of operation is a helpful aid in troubleshooting, and it is recommended that the reader review Section IV of the manual before attempting to troubleshoot the unit in detail. Once the principles of operation are understood, logical application of this knowledge used in conjunction with the normal voltage readings shown on the schematic and the additional procedures given in the following paragraphs should suffice to isolate a fault to a component or small group of components. The normal voltages shown on the schematic are positioned adjacent to the applicable test points (identified by encircled numbers on the schematic and printed wiring board). Additional test procedures that will aid in isolating troubles are as follows:

a. Reference circuit check (Paragraph 5-31). This circuit provides critical operating voltages for the instrument and faults in the circuit could affect the overall operation in many ways.

b. Feedback loop checks (Paragraph 5-32).

c. Procedures for dealing with common troubles (Paragraph 5-33).

5-30 Note that the above mentioned procedures are applicable to both power supply and amplifier operation except in a few cases which are noted in the procedures. Generally speaking, very few troubles that are encountered will affect the operation of the PS/A in only one of its operating modes.

5-31 Reference Circuit. To check the reference circuit, proceed as follows:

a. Turn VOLTS/GAIN control fully clockwise and set MODE switch to SUPPLY.

b. Turn-on unit with no load connected.

c. Proceed as instructed in Table 5-2.

5-32 Feedback Circuit. Generally, malfunction of the feedback circuit is indicated by high or low output voltages. If one of these situations occur, disconnect the load and proceed as instructed in the applicable table (5-3 through 5-6).

5-33 Common Troubles. Table 5-7 provides a tabular list of the symptoms, checks, and probable causes for common troubles.

Table 5-2. Reference Circuit Troubleshooting

Step	Meter Common	Meter Positive	Normal Indication	Action
1	C	28	-28.7 ±3 Vdc	If normal, proceed to step 2. If abnormal, check VR3, C13, R15, CR7 and CR8.
2	C	10	-6.2 ±0.3 Vdc	If abnormal, check VR1, R37, R64, VR5.
3	C	31	+60 ±6 Vdc	If abnormal, check C12, CR5, CR6.
4	C	30	+28.7 ±3 Vdc	If abnormal, check VR4, R17, C20.
5	C	11	+6.2 ±0.3 Vdc	If abnormal, check VR2, R65, R36.

Table 5-3. High Positive Output Voltage Troubleshooting

Step	Measure	Response	Probable Cause
1	Check fuse F2	a. Blown b. Not Blown	a. Q2 or Q3 shorted. CR21 or CR22 open. b. Proceed to Step 2.
2	Voltage between 23 (+) and 25 (-)	a. Less positive than +1.4V b. +1.4V to +1.6V	a. CR21 or CR22 shorted. R7 open. b. Check Q3 for open. Check Q1 for short. Proceed to Step 3.
3	Voltage between C and 15	a. Less positive than +22V b. +22V to +26V	a. Q7 shorted. Q8 open. C6 shorted. b. Proceed to Step 4.
4	Voltage between C and 17	a. More positive than +22V b. +21V to +23V	a. Q6 shorted. C7 shorted. b. Check Q4 or Q5 for short. Check C9, CR12 for short.

Table 5-4. High Negative Output Voltage Troubleshooting

Step	Measure	Response	Probable Cause
1	Voltage between 23 (+) and 25 (-)	a. More positive than +1.5V b. +1.3V to +1.5V	a. CR21 or CR22 open. b Proceed to Step 2.
2	Voltage between 22 (+) and 24 (-)	a. 0V b. +0.5V to 0.8V	a. Q3 shorted b. Check Q2 for short Check R8 for short Proceed to Step 3.
3	Voltage between C and 15	a. More positive than +26V b. +22V to +26V	a. Q7 open Q8 shorted R27 shorted b. Proceed to Step 4
4	Voltage between C and 17	a. More negative than -20V b. -18V to -20V	a. Q6 open R18 or R61 shorted b. Check Q4 or Q5 for open.

Table 5-5. Low Positive Output Voltage Troubleshooting

Step	Measure	Response	Probable Cause
1	Remove Q12 from circuit	a. Normal positive output voltage b. Low positive output voltage	a. Q12 shorted R5 or R1 open or high resistance. b. Reconnect Q12 and check Q1 for open. If normal, proceed to Step 2.

Table 5-5. Low Positive Output Voltage Troubleshooting (Continued)

2	Voltage between C and 15	a. More positive than +26V b. +22V to +26V	a. Open strap between A3 -A4. Check -6.2V reference for low voltage. Check R52A for open. b. Proceed to Step 3.
3	Voltage between C and 17	a. Less positive than +21V.	a. Check R18, R19, and R61 for low resistance or short.

Table 5-6. Low Negative Output Voltage Troubleshooting

Step	Measure	Response	Probable Cause
1	Remove Q11 from circuit	a. Normal negative output voltage b. Low negative output voltage	a. Q11 shorted. R6 or R2 open or high resistance. b. Reconnect Q11 and proceed to Step 2.
2	Voltage between 23 (+) and 25 (-)	a. Less positive than +1.3V b. +1.3V to +1.6V	a. Check CR 21 or CR22 for short. b. Check Q2 for open. Proceed to Step 3.
3	Voltage between C and 15	a. Less positive than +22V. b. +22V to +26V	a. Open strap between A3-A4. Check R52A for open. Check +6.2V reference for low voltage. b. Proceed to Step 4.
4	Voltage between C and 17	a. Less negative than -18V.	a. Check R18, R19, and R61 for high resistance or open.

Table 5-7. Common Troubles

Symptom	Checks and Probable Causes
High ripple	a. Check operating setup for ground loops. b. Ensure that unit is not crossing over to current limiting operation under loaded conditions. (This will be characterized by ripple in the power supply mode and clipping of the positive and negative peaks in the amplifier mode).
Oscillation (power supply mode)	a. Check feedback networks; C6-R25, C7-R24, and C5-R46.
Distortion (amplifier mode)	a. Ensure that unit is not going into current limit operation. b. If high frequency component of output signals are distorted, check feedback networks; C6-R25, C7-R24, and C5-R46.

Table 5-7. Common Troubles (Continued)

Poor Stability	a.	Check reference voltages (Table 5-2).
	b.	Noisy VOLTS/GAIN control (R52A).
	c.	CR27 or CR28 leaky.
	d.	Stage Q7 or Q8 defective.
Unit programs in only one direction	a.	R38 or R39 open
	b.	No +6.2V or -6.2V reference source.
Zero Output	a.	R32 or R52A open
	b.	S2 open.

Excessive heat or pressure can lift the copper strip from the board. Avoid damage by using a low power soldering iron (50 watts maximum) and following these instructions. Copper that lifts off the board should be cemented in place with a quick drying acetate base cement having good electrical insulating properties.

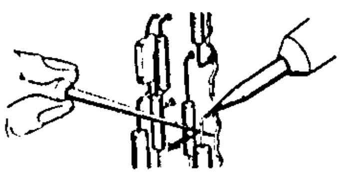
A break in the copper should be repaired by soldering a short length of tinned copper wire across the break.

Use only high quality rosin core solder when repairing etched circuit boards. NEVER USE PASTE FLUX. After soldering, clean off any excess flux and coat the repaired area with a high quality electrical varnish or lacquer.

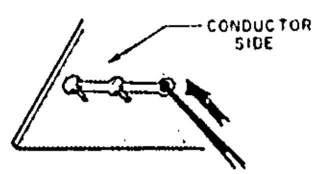
When replacing components with multiple mounting pins such as tube sockets, electrolytic capacitors, and potentiometers, it will be necessary to lift each pin slightly, working around the components several times until it is free.

WARNING: If the specific instructions outlined in the steps below regarding etched circuit boards without eyelets are not followed, extensive damage to the etched circuit board will result.

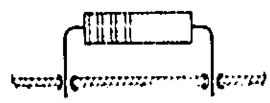
1. Apply heat sparingly to lead of component to be replaced. If lead of component passes through an eyelet in the circuit board, apply heat on component side of board. If lead of component <u>does not</u> pass through an eyelet, apply heat to conductor side of board.



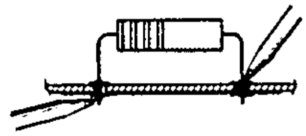
2. Reheat solder in vacant eyelet and quickly insert a small awl to clean inside of hole. If hole <u>does not</u> have an eyelet, insert awl or a #57 drill from conductor side of board.



3. Bend clean tinned leads on new part and carefully insert through eyelets or holes in board.

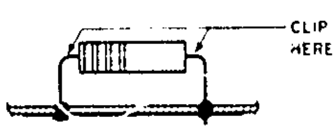


4. Hold part against board (avoid overheating) and solder leads. Apply heat to component leads on correct side of board as explained in step 1.

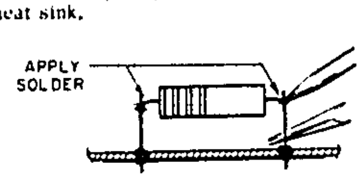


In the event that either the circuit board has been damaged or the conventional method is impractical, use method shown below. This is especially applicable for circuit boards without eyelets.

1. Clip lead as shown below.



2. Bend protruding leads upward. Bend lead of new component around protruding lead. Apply solder using a pair of long nose pliers as a heat sink.



This procedure is used in the field only as an alternate means of repair. It is not used within the factory.

Figure 5-11. Servicing Printed Wiring Boards

Table 5-8. Selected Semiconductor Characteristics

Reference Designator	Characteristics	hp Stock No.	Suggested Replacement	
Q1, 9	NPN Si Power. h_{fe} = 35 (min.) @ I_C = 4A; Vce = 4V.	1854-0225	2N3055	R.C.A.
Q2	PNP Ger. Power. Selected B1654.	---------	B1654	Bendix
CR1-8, 19	Si rectifier, 500ma, 200prv	1901-0026	1N3253	R.C.A.
CR11, 12, 21-28	Si stabistor, 200ma, 10prv	1901-0461	1N4828	G.E.
VR3-5	Zener Diode, 28.7V ±5%, 1W.	1902-0572	1N3031	Motorola

5-34 REPAIR AND REPLACEMENT

5-35 Before servicing a printed wiring board, refer to Figure 5-11. Section VI of this manual contains a tabular list of the instruments replaceable parts. Before replacing a semiconductor device, refer to Table 5-8 which lists the special characteristics of selected semiconductors. If the device to be replaced is not listed in Table 5-8, the standard manufacturers part number listed in Section VI is applicable. After replacing a semiconductor, refer to Table 5-9 for checks and adjustments that may be necessary.

Table 5-9. Checks and Adjustments After Replacement of Semiconductor Devices

Reference	Function	Check	Adjust
Q1, Q2	Regulator/Output Amplifier	Load regulation (Power Supply) Gain/frequency response (Amplifier) Current limit Ammeter/Voltmeter tracking	 R5 and R6 R35/R31
Q4, Q5, Q6	Error and driver amplifiers	Load regulation	
Q7, Q8	Differential Amplifier	Line and load regulation Programming current	 R38 and R39
Q9, Q10	Auxiliary source regulators	Auxiliary outputs (+20V, -20V)	
Q11, Q12	Current limiting transistors	Current limit	R5 or R6
CR1-CR8	Rectifier diodes	Voltage across appropriate filter capacitor	
VR1-VR5	Develop stable reference voltages	Positive and negative reference voltages Line regulation	

Table 5-10. Calibration Adjustment Summary

Adjustment or Calibration	Paragraph	Control Device
Meter Zero	5-38	Pointer
Voltmeter Tracking	5-40	R31
Ammeter Tracking	5-42	R35
Programming Current	5-44	R38 and R39
Current Limit	5-46	R5 and R6

5-36 <u>ADJUSTMENT AND CALIBRATION</u>

5-37 Adjustment and calibration may be required after performance testing, troubleshooting or repair and replacement. Perform only those adjustments that affect the operation of the faulty circuit and no others. Table 5-10 summarizes the adjustments and calibrations contained in the following paragraphs.

5-38 METER ZERO

5-39 Proceed as follows to zero meter:

a. Turn off instrument (after it has reached normal operating temperature) and allow 30 seconds for all capacitors to discharge.

b. Insert sharp pointed object (pen point or awl) into the small indentation near top of round black plastic disc located directly below meter face.

c. Rotate plastic disc clockwise (cw) until meter reads zero, then rotate ccw slightly in order to free adjustment screw from meter suspension. If pointer moves, repeat steps b and c.

5-40 VOLTMETER TRACKING

5-41 To calibrate voltmeter tracking, proceed as follows:

a. Connect differential voltmeter across output. Connect positive lead to common terminal on rear of PS/A.

b. Set METER switch to VOLTS and MODE switch to supply. Adjust VOLTS/GAIN control ccw until differential voltmeter reads exactly the maximum rated negative output voltage.

c. Adjust R31 until front panel meter also indicates maximum rated output voltage.

5-42 AMMETER TRACKING

5-43 To calibrate ammeter tracking proceed as follows:

a. Connect test setup shown on Figure 5-3.

b. Set METER switch to AMPS.

c. Turn on supply and adjust VOLTS/GAIN control cw until differential voltmeter reads 1.0 Vdc.

d. Adjust R35 until front panel meter indicates exactly the maximum rated positive output current.

5-44 PROGRAMMING CURRENT

5-45 To calibrate the programming current, proceed as follows:

a. Connect differential voltmeter across output terminals.

b. Set MODE switch to SUPPLY and turn on unit.

c. Set VOLTS/GAIN control fully cw and FINE/ZERO control to mid-position.

d. Adjust R38 so that differential voltmeter reads +20.2 Vdc (Model 6823A) or +52 Vdc (Model 6824A).

e. Set polarity switch for minus input and rotate VOLTS/GAIN control fully ccw.

f. Adjust R39 so that differential voltmeter reads -20.2 Vdc (Model 6823A) or -52 Vdc (Model 6824A).

5-46 CURRENT LIMIT ADJUSTMENT

5-47 To adjust the current limit so that the unit can be used to furnish maximum rated output current, proceed as follows:

a. Connect test setup shown in Figure 5-3 except connect variable transformer between input source and PS/A.

b. Short out load resistor (Ry).

c. Set MODE switch to SUPPLY. Adjust variable transformer for 105 Vac input (low line).

d. Turn on supply and rotate VOLTS/GAIN controls fully clockwise.

e. Adjust R5 until differential voltmeter indicates +1.5 Vdc for Model 6823A or +1.2 Vdc for Model 6824A. Set position of input polarity switch for minus input and rotate VOLTS/GAIN control fully ccw.

f. Adjust R6 until differential voltmeter indicates -1.5 Vdc for Model 6823A units or -1.2 Vdc for Model 6824A units.

PARTS LIST

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts.

6-3 Table 6-4 lists parts in alpha-numerical order of the reference designators and provides the following information:

a. Reference Designators. For abbreviations, refer to Table 6-1.

b. Description. Refer to Table 6-2 for abbreviations.

c. Total Quantity (TQ) used in the instrument; given only first time the part number is listed.

d. Manufacturer's part number.

e. Manufacturer's code number. Refer to Table 6-3 for manufacturer's name and address.

f. HP Part Number.

g. Recommended spare parts quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-4 under Miscellaneous.

6-4 ORDERING INFORMATION

6-5 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses).

6-6 Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard part number.

c. Circuit reference designator.

d. Description.

6-7 To order a part not listed in Table 6-4, give a complete description of the part and include its function and location.

Table 6-1. Reference Designators

A = assembly	CR = diode
B = motor	DS = device, signaling (lamp)
C = capacitor	

Table 6-1. Reference Designators (Continued)

E = misc. electronic part	RT = thermistor
F = fuse	S = switch
J = jack	T = transformer
K = relay	V = vacuum tube, neon bulb, photocell, etc.
L = inductor	
M = meter	X = socket
P = plug	XF = fuseholder
Q = transistor	XDS = lampholder
R = resistor	Z = network

Table 6-2. Description Abbreviations

a = amperes	obd = order by description
c = carbon	
cer = ceramic	p = peak
coef = coefficient	pc = printed circuit board
com = common	
comp = composition	pf = picofarads = 10^{-12} farads
conn = connection	
crt = cathode-ray tube	pp = peak-to-peak
	ppm = parts per million
dep = deposited	pos = position(s)
elect = electrolytic	poly = polystyrene
encap = encapsulated	pot = potentiometer
f = farads	prv = peak reverse voltage
fxd = fixed	
GE = germanium	rect = rectifier
grd = ground(ed)	rot = rotary
h = henries	rms = root-mean-square
Hg = mercury	s-b = slow-blow
impg = impregnated	sect = section(s)
ins = insulation(ed)	Si = silicon
K = kilo = 1000	sil = silver
lin = linear taper	sl = slide
log = logarithmic taper	td = time delay
	TiO_2 = titanium dioxide
mA = milli = 10^{-3}	tog = toggle
M = megohms	tol = tolerance
ma = milliamperes	trim = trimmer
μ = micro = 10^{-6}	twt = traveling wave tube
mfr = manufacturer	
mtg = mounting	var = variable
my = mylar	w/ = with
NC = normally closed	W = watts
	w/o = without
Ne = neon	cmo = cabinet mount only
NC = normally open	

Table 6-3. Code List of Manufacturers

CODE NO.	MANUFACTURER	ADDRESS
00629	EBY Sales Co.	New York, N.Y.
00656	Aerovox Corp.	New Bedford, Mass.
00853	Sangamo Electric Company, Ordill Division (Capacitors)	Marion, Ill.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc. Semiconductor-Components Division	Dallas, Texas
01686	RCL Electronics, Inc.	Manchester, N.H.
01930	Amerock Corp.	Rockford, Ill.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02606	Fenwal Laboratories	Morton Grove, Ill.
02660	Amphenol-Borg Electronics Corp.	Broadview, Ill.
02735	Radio Corp. of America, Commercial Receiving Tube and Semiconductor Div.	Somerville, N.J.
03508	G. E. Semiconductor Products Dept.	Syracuse, N.Y.
03797	Eldema Corp.	Compton, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co.	Cedar Knolls, N.J.
04009	Arrow, Hart and Hegeman Electric Co.	Hartford, Conn.
04072	ADC Electronics, Inc.	Harbor City, Calif.
04213	Caddell-Burns Mfg. Co. Inc.	Mineola, N.Y.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04713	Motorola, Inc., Semiconductor Products Division	Phoenix, Arizona
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	Grand Junction, Colo.
05820	Wakefield Engr. Inc.	Wakefield, Mass.
06004	The Bassick Co.	Bridgeport, Conn.
06486	IRC, Inc. Semiconductor Div.	Lynn, Mass.
06540	Amathom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Nuclear Corp. of America, Inc. U.S. Semcor Div.	Phoenix, Arizona
06812	Torrington Mfg. Co., West Div.	Van Nuys, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07263	Fairchild Semiconductor Div. of Fairchild Camera and Instrument Corp.	Mountain View, Calif.
07387	Bircher Corp., The	Los Angeles, Calif.
07397	Sylvania Electric Products Inc. Mountain View Operations of Sylvania Electronic Systems	Mountain View, Calif.
07716	I. R. C. Inc.	Burlington, Iowa
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
08484	Breeze Corporations, Inc.	Union, N.J.
08530	Reliance Mica Corp.	Brooklyn, N.Y.
08717	Sloan Company	Sun Valley, Calif.
08730	Vemaline Products Co.	Franklin Lakes, N.J.
08863	Nylomatic Corp.	Morrisville, Pa.
09021	Airco Speer Electronic Components	Bradford, Pa.
09182	Hewlett-Packard Co., New Jersey Div.	Berkeley Heights, N.J.
09353	C & K Components	Newton, Mass.
09922	Burndy Corp.	Norwalk, Conn.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11502	IRC Inc.	Boone, N.C.
11711	General Instrument Corp., Semiconductor Prod. Group, Rectifier Div.	Newark, N.J.
12136	Philadelphia Handle Co., Inc.	Camden, N.J.
12615	U.S. Terminals, Inc.	Cincinnati, Ohio
12617	Hamlin Inc.	Lake Mills, Wisconsin
12697	Clarostat Mfg. Co.	Dover, N.H.
14493	Hewlett-Packard Co., Loveland Division	Loveland, Colo.
14655	Cornell-Dubilier Elec. Corp.	Newark, N.J.
14936	General Instrument Corp., Semiconductor Prod. Group, Semiconductor Div.	Hicksville, N.Y.
15909	Daven Div. of Thos. Edison Industries, Mc Graw Edison Co.	Livingston, N.J.
16299	Corning Glass Works, Electronic Components Div.	Raleigh, N.C.
16758	Delco Radio Div. of General Motors Corp.	Kokomo, Ind.
17[illegible]5	Atlantic Semiconductors, Inc.	Asbury Park, N.J.
17803	Fairchild	Mountainview, Calif.
19315	The Bendix Corp., Eclipse Pioneer Div.	Teterboro, N.J.
19701	Electra Mfg. Co.	Independence, Kan.

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
22229	Union Carbide Corp., Linde Div., Kemet Dept.	Mountain View, Calif.
22767	ITT Semiconductors, A Division of International Telephone & Telegraph Corp.	Palo Alto, Calif.
24446	General Electric Co.	Schenectady, N.Y.
24455	General Electric Co., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26982	Dynacool Mfg. Co. Inc	Saugerties, N.Y.
27014	National Semiconductor Corp.	Santa Clara, Calif.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
28520	Heyman Mfg. Co.	Kenilworth, N.J.
33173	G.E., Tube Dept.	Owensboro, Ky.
35434	Lectrohm, Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
42190	Muter Co.	Chicago, Ill.
43334	New Departure-Hyatt Bearings Div., General Motors Corp.	Sandusky, Ohio
44655	Ohmite Manufacturing Co.	Skokie, Ill.
46384	Penn Engr.	Doylestown, Pa.
47904	Polaroid Corp.	Cambridge, Mass.
49956	Raytheon Mfg. Co., Microwave and Power Tube Div.	Waltham, Mass.
55026	Simpson Electric Co.	Chicago, Ill.
56289	Sprague Electric Co.	North Adams, Mass.
58474	Superior Electric Co.	Bristol, Conn.
61637	Union Carbide Corp.	New York, N.Y.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
70563	Amperite Co., Inc.	Union City, N.J.
70901	Beemer Engrg. Co.	Fort Washington, Pa.
70903	Belden Mfg. Co.	Chicago, Ill.
71218	Bud Radio, Inc.	Willoughby, Ohio
71279	Cambridge Thermionic Corp.	Cambridge, Mass.
71400	Bussmann Mfg. Div. of Mc Graw-Edison Co.	St. Louis, Mo.
71450	CTS Corporation	Elkhart, Ind.
71468	I. T. T. Cannon Electric Inc.	Los Angeles, Calif.
71590	Centralab Div. of Globe Union, Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71707	Coto-Coil	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71785	Cinch Mfg. Co.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro-Motive Mfg. Co. Inc., The	Willimantic, Conn.
72619	Dialight Corp.	Brooklyn, N.Y.
72699	General Instrument Corp., Capacitor Div.	Newark, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72962	Elastic Stop Nut Corp. of America	Union, N.J.
72982	Erie Technological Products, Inc.	Erie, Pa.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73168	Fenwal, Inc.	Ashland, Mass.
73293	Hughes Components Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73734	Federal Screw Porducts, Inc.	Chicago, Ill.
73978	Hardwick Hindle Co., Memcor Components Div.	Huntington, Ind.
74193	Heinemann Electric Co.	Trenton, N.J.
74545	Harvey Hubbel, Inc.	Bridgeport, Conn.
74868	FXR Div. of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75183	Howard B. Jones Div., of Cinch Mfg. Corp. (Use 71785)	New York, N.Y.
75382	Kulka Electric Corp.	Mt. Vernon, N.Y.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76381	Minnesota, Mining & Mfg. Co.	St. Paul, Minn.
76493	J. W. Miller Co.	Los Angeles, Calif.
76530	Cinch	City of Industry, Calif.
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., Bendix-Pacific Div.	No. Hollywood, Calif.
77147	Patton Mac Guyer Co.	Providence, R.I.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine and Foundry, Potter and Brumfield Div.	Princeton, Ind.
77630	TRW Electronics, Components Div.	Camden, N.J.
77764	Resistance Products Co.	Harrisburg, Pa.
78189	Shakeproof Div. of Illinois Tool Works	Elgin, Ill.
78452	Everlock Chicago, Inc.	Chicago, Ill.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78526	Stanwyck Winding Co., Inc.	Newburgh, N.Y.
78553	Tinnerman Products, Inc.	Cleveland, Ohio

Table 6-3. Code List of Manufacturers (Continued)

CODE NO.	MANUFACTURER	ADDRESS
78584	Stewart Stamping Corp.	Yonkers, N.Y.
79136	Waldes Kohinoor, Inc.	L.I.C., N.Y.
79307	Whitehead Metal Products Co., Inc.	New York, N.Y.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
80031	Mepco Div. of Sessions Clock Co.	Morristown, N.J.
80294	Bourns, Inc.	Riverside, Calif.
81042	Howard Industries, Inc.	Racine, Wis.
81483	International Rectifier Corp.	El Segundo, Calif.
81751	Columbus Electronics Corp.	Yonkers, N.Y.
82099	Goodyear Sundries & Mechanical Co., Inc.	New York, N.Y.
82142	Airco Speer Electronic Components	Du Bois, Pa.
82219	Sylvania Electric Products, Inc., Electronic Tube Division	Emporium, Pa.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals and Controls, Inc., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Eatontown, N.J.
83330	Herman H. Smith, Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co., Div. of Amerace Corp.	Brookfield, Mass.
83508	Grant Pulley and Hardware Co.	West Nyack, N.Y.
83594	Burroughs Corp., Electronic Components Div.	Plainfield, N.J.
83835	U.S. Radium Corp.	Morristown, N.J.
83877	Yardeny Laboratories, Inc.	New York, N.Y.
84171	Arco Electronics, Inc.	Great Neck, N.Y.
84411	TRW Capacitor Div.	Ogallala, Neb.
86684	Radio Corp. of America, Electronic Components & Devices Div.	Harrison, N.J.
86838	Rummel Fibre Co.	Newark, N.J.
87034	Marco Industries Co.	Anaheim, Calif.
87216	Philco Corp. (Lansdale Div.)	Lansdale, Pa.

CODE NO.	MANUFACTURER	ADDRESS
87585	Stockwell Rubber Co., Inc.	Philadelphia, Pa.
87929	B.M. Tower Co., Inc.	Bridgeport, Conn.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
91345	Miller Dial and Nameplate Co.	El Monte, Calif.
91637	Dale Electronics, Inc.	Columbus, Neb.
91662	Elco Corp.	Willow Grove, Pa.
91929	Honeywell, Inc., Micro Switch Div.	Freeport, Ill.
93332	Sylvania Electric Prod., Inc., Semiconductor Prod. Div.	Woburn, Mass.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
94144	Raytheon Co., Components Div., Industrial Components Operation	Quincy, Mass.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94222	South Chester Corp.	Chester, Pa.
94310	Tru-Ohm Products, Memcor Components Div.	Huntington, Ind.
95263	Leecraft Mfg. Co., Inc.	Long Island City, N.Y.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Bendix Corp, Microwave Div.	Franklin, Ind.
96791	Amphenol Controls Div. of Amphenol-Borg Electronics Corp.	Janesville, Wis.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99934	Renbrandt, Inc.	Boston, Mass.

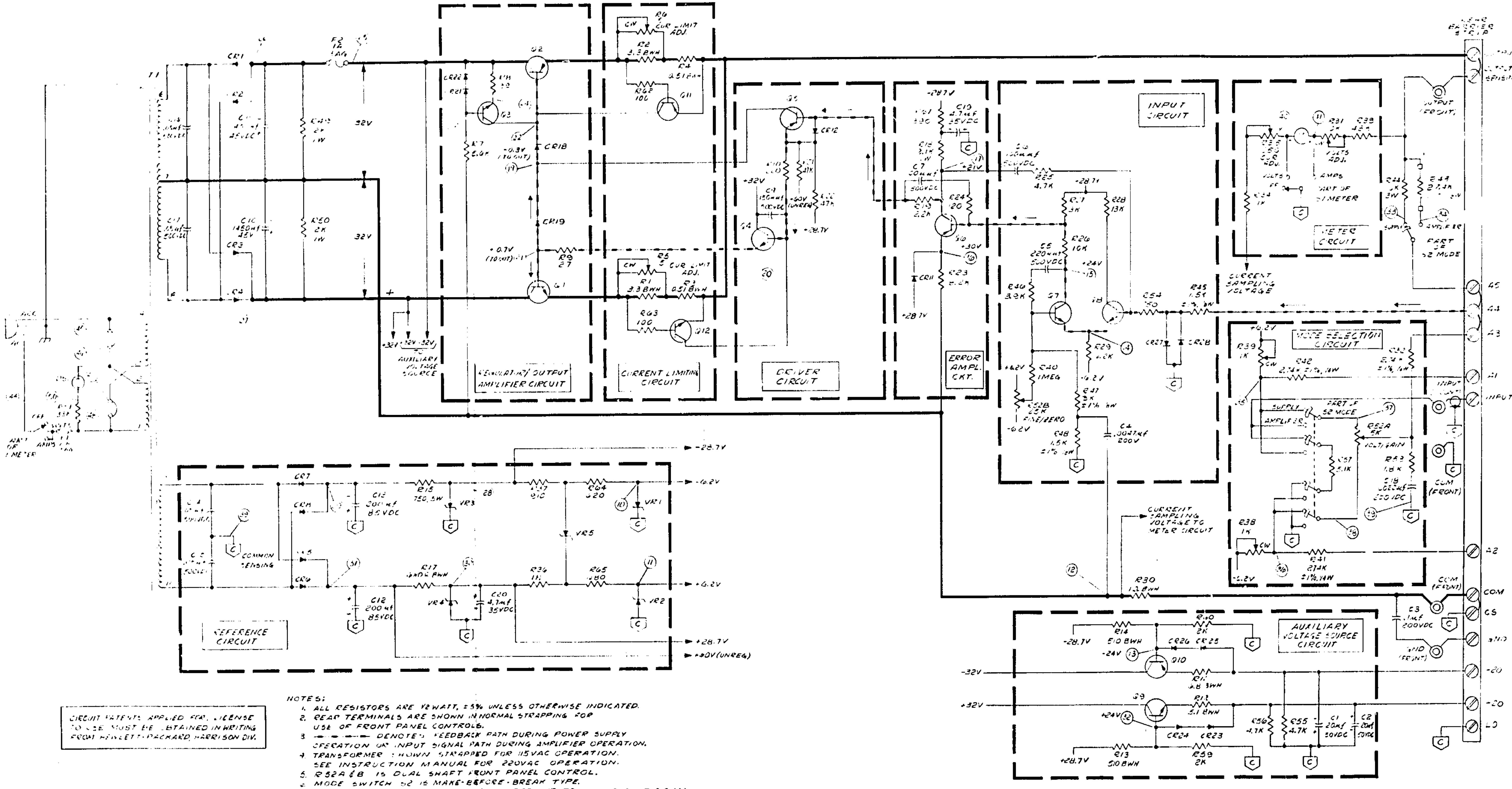
THE FOLLOWING H-P VENDORS HAVE NO NUMBERS ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

CODE NO.	MANUFACTURER	ADDRESS
0000	Cooltron	Oakland, Calif.
00000	Plastic Ware Co.	Brooklyn, N.Y.

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	hp Stock No.	RS
C1, 2	fxd. elect 20μf 50vdc	2	300206G050DC4	Sprague	56289	0180-0049	1
C3	fxd. film .1μf 200vdc	1	192P10492	Sprague	56289	0160-0168	1
C4	fxd. film .0047μf 200vdc	1	192P47292	Sprague	56289	0160-0157	1
C5	fxd. mica 220μμf 500vdc	1	RCM15E221J	Arco	84171	0140-0068	1
C6, 7	fxd. mica 100μμf 500vdc	2	RCM15E101J	Arco	84171	0140-0041	1
C8	NOT ASSIGNED	-	-	-	-	-	-
C9	fxd. mica 150μμf 500vdc	1	RCM15E151J	Arco	84171	0140-0067	1
C10, 11	fxd. elect 1450μf 45vdc	2	D39532	HLAB	09182	0180-1893	1
C12, 13	fxd. elect 200μf 85vdc	2	D31642	HLAB	09182	0180-1854	1
C14-17	fxd. ceramic .05μf 500vdc	4	33C17A	Sprague	56289	0150-0052	1
C18	fxd. film .0022μf 200vdc	1	192P22292	Sprague	56289	0160-0154	1
C19, 20	fxd. elect 4.7μf 35vdc	2	150D475X9035B2	Sprague	56289	0180-0100	1
CR1-8, 19	Rect. si. 500ma 200prv	9	1N3253	R.C.A.	02735	1901-0389	6
CR9, 10, 13-17, 20	NOT ASSIGNED	-	-	-	-	-	-
CR11, 12, 21-28	Rect. si. 200ma 10prv	10		HLAB	09182	1901-0461	6
CR18	Rect. si. 150ma 100prv	1	1N91	G.E.	03508	1911-0001	1
DS1	Indicator, light neon	1	599-124	Drake	72765	1450-0048	1
F1	Fuse cartridge (AC) 2A @ 250V 3AG	1	312002	Littlefuse	75913	2110-0002	5
F2	Fuse cartridge (DC) 1A @ 250V 3AG	1	312001	Littlefuse	75913	2110-0001	5
Q1, 9	Power NPN si.	2		HLAB	09182	1854-0225	2
Q2	Power PNP ger. (SELECTED)	1	B1654	HLAB	09182		1
Q3, 4	SS NPN si.	2	40422	R.C.A.	02735	1854-0068	2
Q5, 11	SS PNP si.	2	2N2907A	Sprague	56289	1853-0099	2
Q6	SS PNP si.	1	40362	R.C.A.	02735	1853-0041	1
Q7, 8	SS NPN si.	2	2N3417	G.E.	03508	1854-0087	2
Q10	Power PNP si.	1	2N2147	R.C.A.	02375	1850-0160	1
Q12	SS NPN si.	1	4JX16A1014	G.E.	03508	1854-0071	1
R1, 2	fxd. ww 3.3Ω ±5%	2	Type BWH	I.R.C.	07716	0811-1672	1
R3, 4	fxd. ww .51Ω ±5%	2	Type BWH	I.R.C.	07716	0811-0929	1
R5, 6	var. ww .5Ω	2	Type 110-F4	C.T.S.	11236	2100-1821	1
R7	fxd. comp 5.6KΩ ±5% ½w	1	EB-5625	A.B.	01121	0686-5625	1
R8	fxd. comp 39Ω ±5% ½w	1	EB-3905	A.B.	01121	0686-3905	1
R9	fxd. comp 27Ω ±5% ½w	1	EB-2705	A.B.	01121	0686-2705	1
R10	fxd. comp 220Ω ±5% ½w	1	EB-2215	A.B.	01121	0686-2215	1
R11	fxd. ww 6.8Ω ±5%	1	Type BWH	I.R.C.	07716	0811-1676	1
R12	fxd. ww 5.1Ω ±5%	1	Type BWH	I.R.C.	07716	0811-1761	1
R13, 14	fxd. ww 510Ω ±5%	2	Type BWH	I.R.C.	07716	0811-1766	1
R15	fxd. ww 750Ω ±5% 5W	1	Type 243E	Sprague	56289	0811-1861	1
R16, 20, 58	NOT ASSIGNED	-	-	-	-	-	-
R17	fxd. ww 680Ω ±5% 5W	1	Type 243E	Sprague	56289	0811-2099	1
R18	fxd. comp 9.1KΩ ±5% 1W	1	GB-9125	A.B.	01121	0689-9125	1
R19	fxd. comp 2.2KΩ ±5% ½w	1	EB-2225	A.B.	01121	0686-2225	1
R21	fxd. comp 20KΩ ±5% ½w	1	EB-2035	A.B.	01121	0686-2035	1
R22	fxd. comp 47KΩ ±5% ½w	1	EB-4735	A.B.	01121	0686-4735	1
R23	fxd. comp 8.2KΩ ±5% ½w	1	EB-8225	A.B.	01121	0686-8225	1
R24	fxd. comp 120Ω ±5% ½w	1	EB-1215	A.B.	01121	0686-1215	1
R25, 55, 56	fxd. comp 4.7KΩ ±5% ½w	3	EB-4725	A.B.	01121	0686-4725	1

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	ℏ Stock No.	RS
R26	fxd, comp 10KΩ ±5% ½w	1	EB-1035	A. B.	01121	0686-1035	1
R27	fxd, comp 3KΩ ±5% ½w	1	EB-3025	A. B.	01121	0686-3025	1
R28	fxd, comp 13KΩ ±5% ½w	1	EB-1335	A. B.	01121	0686-1335	1
R29	fxd, comp 6.2KΩ ±5% ½w	1	EB-6225	A. B.	01121	0686-6225	1
R30	fxd, ww 1Ω ±5%	1	Type BWH	I. R. C.	07716	0811-1666	1
R31	var, comp 10KΩ	1	Series 70	C. T. S.	11236	2100-0092	1
R32, 41, 42	fxd, met. film 2.74KΩ ±1% ¼w	3	Type CEB T-O	I. R. C.	07716	0757-0742	1
R33	fxd, comp 43KΩ ±5% ½w	1	EB-4335	A. B.	01121	0686-4335	1
R34, 37	fxd, comp 910Ω ±5% ½w	2	EB-9115	A. B.	01121	0686-9115	1
R35	var, ww 250Ω	1	Type 110-F4	C. T. S.	11236	2100-0439	1
R36	fxd, comp 1KΩ ±5% ½w	1	EB-1025	A. B.	01121	0686-1025	1
R38, 39	var, ww 1KΩ	2	Type 110-F4	C. T. S.	11236	2100-0391	1
R40	fxd, comp 1 MEGΩ ±5% ½w	1	EB-1055	A. B.	01121	0686-1055	1
R43	fxd, met. film 27.4K ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-0452	1
R44	fxd, ww 10KΩ ±5% 3W	1	242E1035	Sprague	56289	0811-1816	1
R45, 48	fxd, met. film 1.5KΩ ±1% 1/8w	2	Type CEA T-O	I. R. C.	07716	0757-0427	1
R46	fxd, comp 3.9KΩ ±5% ½w	1	EB-3925	A. B.	01121	0686-3925	1
R47	fxd, met. film 3KΩ ±1% 1/8w	1	Type CEA T-O	I. R. C.	07716	0757-1093	1
R49, 50	fxd, comp 2KΩ ±5% 1W	2	GB-2025	A. B.	01121	0689-2025	1
R51	fxd, comp 33KΩ ±5% ½w	1	EB-3335	A. B.	01121	0686-3335	1
R52	var, ww DUAL 5K - 25K	1		HLAB	09182	2100-1805	1
R53	fxd, comp 1.8KΩ ±5% ½w	1	EB-1825	A. B.	01121	0686-1825	1
R54	fxd, comp 750Ω ±5% ½w	1	EB-7515	A. B.	01121	0686-7515	1
R57	fxd, comp 5.1KΩ ±5% ½w	1	EB-5125	A. B.	01121	0686-5125	1
R59, 60	fxd, comp 2KΩ ±5% ½w	2	EB-2025	A. B.	01121	0686-2025	1
R61	fxd, comp 390Ω ±5% ½w	1	EB-3915	A. B.	01121	0686-3915	1
R62, 63	fxd, comp 100Ω ±5% ½w	2	EB-1015	A. B.	01121	0686-1015	1
R64	fxd, comp 620Ω ±5% ½w	1	EB-6215	A. B.	01121	0686-6215	1
R65	fxd, comp 680Ω ±5% ½w	1	EB-6815	A. B.	01121	0686-6815	1
S1	Switch, Wafer ON/OFF	1		HLAB	09182	3100-1907	1
S2	Switch, Wafer - meter	1		HLAB	09182	3100-1908	1
T1	Power transformer	1		HLAB	09182	9100-1894	1
VR1, 2	Diode Zener 6.2V ±5%	2	1N821	N. A. Elect.	06486	1902-0761	2
VR3 -5	Diode Zener 28.7V ±5% 1W	3		HLAB	09182	1902-0572	3
	Side chassis - right	1		HLAB	09182	5000-6057	
	Side chassis - left	1		HLAB	09182	5000-6058	
	Bracket - heat sink	2		HLAB	09182	5000-6060	
	Blank panel - front	1		HLAB	09182	5000-6062	
	Panel front	1		HLAB	09182	06823-00001	
	Cover	2		HLAB	09182	5000-6061	
	Guard-angle	1		HLAB	09182	5020-5540	
	5 Way binding post (maroon)	2	DF21Mn.	HLAB	09182	1510-0040	1
	5 Way binding post (black)	3	DF21BC	Superior	58474	1510-0039	1
	Fastener	1	C17373-012-24B	Tinnerman	89032	0510-0123	1
	Cable clamp	1	T4-4	Whitehead	79307	1400-0330	1
	Line cord plug PH151 7½ft.	1	HK-4096	Beldon	70903	8120-0050	1
	Strain relief bushing	1	SR-5P-1	Heyco	28520	0400-0013	1
	Knob ¼ insert pointer	2		HLAB	09182	0370-0084	1
	Knob 17/64 insert pointer	1		HLAB	09182	0370-0101	1
	Knob 3/16 insert pointer	1		HLAB	09182	0370-0179	1
	Jumper	4	422-13-11 013	Cinch	71785	0360-1143	1
	Barrier strip	1		HLAB	09182	0360-1234	1

Reference Designator	Description	Quantity	Mfr. Part # or Type	Mfr.	Mfr. Code	hp Stock No.	RS
	Rubber bumper	4	MB50	Stockwell	87575	0403-0088	1
	Rubber bumper	3	4072	Stockwell	87575	0403-0086	1
	Fuse holder	1	342014	Littlefuse	75915	1400-0084	1
	Lockwasher	1	1224-08	Shakeproof	78189	2190-0037	1
	Nut	1	903-12	Littlefuse	75915	2950-0038	1
	Washer-neoprene	1	901-2	Littlefuse	75915	1400-0090	1
	Meter 2¼" DUAL ±0-24V ±0-.6A	1		HLAB	09182	1120-1123	1
	Spring	4		HLAB	09182	1460-0720	1
	Bezel 1/6 MOD	1		HLAB	09182	5040-0651	1
	Fastener	8	C8091-632-24B	Tinnerman	89032	0510-02[illegible]	2
	Mica insulator	4	734	Reliance	08530	0340-0174	1
	Insulator, transistor pin	8		HLAB	09182	0340-0166	1
	Insulator	8		HLAB	09182	0340-0198	1



CIRCUIT PATENTS APPLIED FOR. LICENSE TO USE MUST BE OBTAINED IN WRITING FROM HEWLETT-PACKARD, HARRISON DIV.

NOTES:

1. ALL RESISTORS ARE 1/2 WATT, ±5% UNLESS OTHERWISE INDICATED.
2. REAR TERMINALS ARE SHOWN IN NORMAL STRAPPING FOR USE OF FRONT PANEL CONTROLS.
3. — — — — DENOTES FEEDBACK PATH DURING POWER SUPPLY OPERATION OR INPUT SIGNAL PATH DURING AMPLIFIER OPERATION.
4. TRANSFORMER SHOWN STRAPPED FOR 115VAC OPERATION. SEE INSTRUCTION MANUAL FOR 220VAC OPERATION.
5. R52A & B IS DUAL SHAFT FRONT PANEL CONTROL.
6. MODE SWITCH S2 IS MAKE-BEFORE-BREAK TYPE.
7. DC VOLTAGES WERE MEASURED UNDER THE FOLLOWING CONDITIONS:
   1. SI.ASON MODEL 260, OR EQUIVALENT
   2. 115VAC INPUT
   3. VOLTAGES REFERENCED TO CS UNLESS OTHERWISE INDICATED
   4. VOLTAGES ARE TYP'CAL ±10% UNLESS OTHERWISE INDICATED
   5. ALL READINGS TAKEN WITH UNIT IN POWER SUPPLY OPERATION AT MAXIMUM RATED POSITIVE OUTPUT WITH NO LOAD CONNECTED. UNDER LOADED CONDITIONS VOLTAGES SHOULD DECREASE BY APPROXIMATELY 10%.

Model 6823A, Schematic Diagram

MANUAL CHANGES

Model 6823A DC Power Supply
Manual Serial Number Prefix 6B

Make all corrections in the manual according to errata below, then check the following table for your power supply serial number and enter any listed change(s) in the manual.

SERIAL		MAKE CHANGES
Prefix	Number	
6B	0501 - 0790	1
6B	0791 - 1170	1, 2
ALL	-	Errata
1150A	1171 - 1245	1, 2, 3
1150A	1246 - up	1 thru 4

CHANGE 1:

In the replaceable parts table make the following changes:
Q2: Change to Power PNP Ger., B213002, 09182, HP Part No. 1850-0407.
R34: Change to fxd. comp 1KΩ ±5% ½W, EB-1025, A.B., HP Part No. 0686-1025.

CHANGE 2:

In the replaceable parts table, change transistors Q3 and Q4 to RCA 2N4240, HP Part No. 1854-0311.

ERRATA:

In the replaceable parts table, change the HP Part No. of the fuse clip to 2110-0257.

Change Q5 and Q11 to SS PNP Si., 2N2907A, Sprague, HP Part No. 1853-0099.

CHANGE 3:

The serial number prefix has been changed to "1150A."

The standard colors for this instrument are now mint gray (for front and rear panels) and olive gray (for all top, bottom, side, and other external surfaces). Option X95 designates use of the former color scheme of light gray and blue gray. Option A85 designates use of a light gray front panel with olive gray used for all other external surfaces. New part numbers are shown below.

▶ ERRATA:

In the Mode Selection Circuit block of the schematic reverse the designations of test points 37 and 38.

▶ CHANGE 4:

In the Replaceable Parts List on page 6-5, change the HP Stock No. of transistor Q10 from 1850-0160 to 1850-0168.

3-12-73

DESCRIPTION	HP PART NO.		
	STANDARD	OPTION A85	OPTION X95
Front Panel	06823-00002	06823-00001	SEE MANUAL PARTS LIST
Chassis, Right Side	5000-9422	←	↓
Chassis, Left Side	5000-9423	←	↓
Cover (2)	5000-9424	←	↓
Rack Kit, 1 unit (accy)	14515A	14515A-A85	↓
Rack Kit, 2 units "	14525A	14525A-A85	↓