EXPERIMENT NO.07
POWER SUPPLY TROUBLESHOOTING

BASIC INFORMATION:

POSITIVE AND NEGATIVE SUPPLY:

It is frequently necessary to provide a source of V - and V + voltage, measured with respect to a common return. A simple modification of the V + Supply in **(Fig. 5 – 4)** will achieve this (see **Fig. 6 - 1** on the next page). The circuit in **Fig. 6 - 1** is the same as that in **Fig. 5 - 4**, except that RB, the bleeder resistor, has been replaced by two resistors, RB1 and RB2, and filter capacitors C3 and C4 have been added.

The junction of R_{B1} and R_{B2}, point G, is chosen as the common reference or "ground" point. Point P_1 is positive and P_2 is negative with respect to G. V + is therefore taken from P_1 to G and V - from P_2 to G. The resistance ratio of the divider R_{B1} and R_{B2}, in conjunction with the respective load resistances of V + and V -, determines the amplitude of V + and V - voltage. Note that the total value of voltages V + to V - for similar loading conditions is the same as V + to ground in the circuit of **(Fig. 5 – 4)**. The circuit of (**Fig. 6 - 1)** has not increased the total dc voltage output of the power supply. It has reduced the available positive voltage V + (P_1 to G) by the amount of negative voltage V - (P_2 to G).

C1, C2, C3, and C4 are electrolytic capacitors, and it is therefore necessary to observe proper polarity in connecting them in the circuit. Note that the polarity of C3 has been properly indicated because point G is positive with respect to P2.

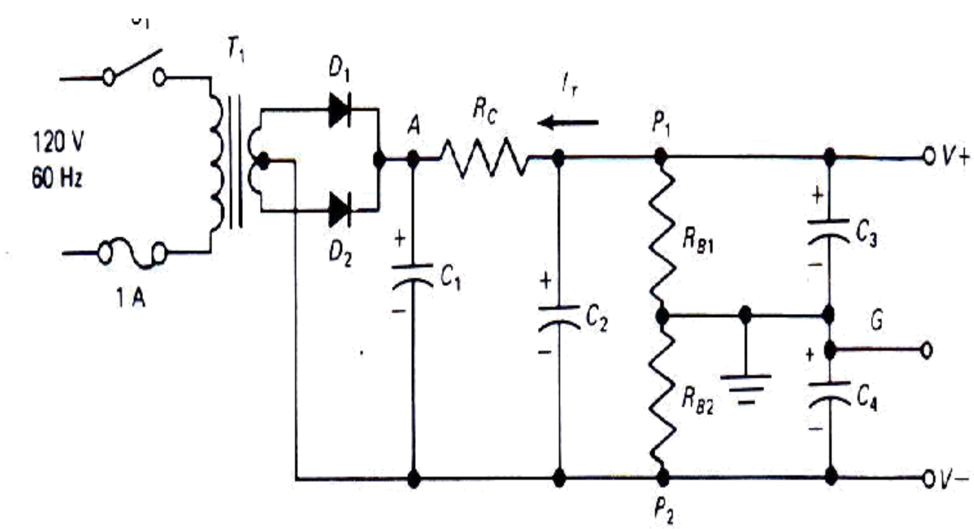

FIG 6 - 1 Power supply connected to furnish V + and V - with respect to common return G.

VOLTAGE, RIPPLE, AND RESISTANCE ANALYSIS OF A POWER SUPPLY:

In troubleshooting a defective power supply it is necessary for the technician to know the normal values of dc and ac voltage, ripple, and resistance expected at test points in the circuit. DC and ac voltages and resistances are measured with a volt-ohm-milli ammeter (VOM) or an electronic volt-ohm-millimeter (EVM). Ripple measurements are made with an oscilloscope.

DC VOLTAGE AND RIPPLE:

Consider the circuit of **Fig. 5-4**. The dc voltage measured from point A to G is approximately equal to one-half the peak-to-peak ac voltage across the secondary winding of T1. The output dc voltage (V +), point P with respect to G, is lower than the voltage from A to C. However, V + is much better filtered (it has a lower ripple) than the voltage from A to G. The ripple voltage at A and P increases with load. V +, however, should have a very low ripple voltage, even at full load. The size of the electrolytic filter capacitors therefore depends on the extent of the load current and on the level of ripple voltage which the circuit can tolerate.

The voltage V + in Fig. 5-4 can be found if the dc volt age V_{AG}, the total dc current I_T drawn from the supply, and the filter resistor R_C are known, since

$$\mathbf{V+ = V_{AG} - I_T \times R_C} \qquad \mathbf{(6\text{-}1)}$$

Example. Determine V + in the circuit of Fig. 5-4, if the peak-to-peak voltage across the secondary of T1 is 50 V. RC = 100Ω, and IT= 0.1 A.

Solution. VAG = 1/2 X 50 (approx.) = 25 V. Therefore

$$V+ = 25-0.1\ (100) = 15V$$

A leaky capacitor C1 or C2 reduces the output voltage V +, and the ripple voltage increases. If capacitor C1 or C2 is open, this reduces V + appreciably, and causes a large increase in ripple.

AC VOLTAGE:

Under normal operation the line voltage (120 V/60 Hz in Fig. 6-1) is present across the primary of transformer T1. The voltage specified for the secondary of the transformer should be measured across the secondary winding. Line voltage and voltages across the one or more secondary windings of a transformer are given in rms values. Voltages measured from the anodes of D1 and D2, respectively, to the center tap on the secondary should be approximately equal to one-half the measured value across the secondary winding. AC voltage in a transformer power supply such as that in**(Fig.6- 1)** and **5-4** is limited to the voltage across the primary winding (line voltage), to the voltages across each of the secondary windings, and to the voltages from each end of a secondary winding to any tap on that winding.

RESISTANCE:

NOTE: *Before measuring resistance, turn power off and discharge all electrolytic capacitors.*

Resistance measurements in (Fig. 6 - 1) are made from V+ to V - to determine whether C1 or C2 is short-circuited. Other resistance measurements may be made to determine continuity of the transformer windings and the resistance of RC or the choke, the bleeder resistor, the on-off switch, and the rectifier diodes.

. Where the circuit arrangement makes it impossible to measure the resistance of a component without measuring the combination resistance of another component in parallel with it, it may be necessary to disconnect one end of the component from the circuit and then measure. Specific resistance values are related to the parameters of the circuit. The following are suggested as guidelines in the circuit of Fig. 6-1, where C1 and C2 are 100-μ F, 50-V capacitors, RC = 100Ω , RB1 and RB2 =5000 Ω, the load is disconnected, and T1 is a 4:1 stepdown transformer whose secondary winding is rated at 1 A. C3 and C4 are 25 -μ F 50-V capacitors.

- P1 to P2, 10,000Ω
- A to P2, 10,000Ω
- RC (A to P1), 100Ω
- Forward resistance (RF) of D1 or D2 ≤500Ω
- Back resistance (RR) of D1 or D2 > 1MΩ
- Resistance of secondary winding of T1 = 0.2Ω
- Resistance of primary winding of T1 = 1.2Ω

When the bleeder and load are both disconnected from the circuit, capacitors C1 and C2 give a charging indication when an ohmmeter is first connected from point P1 or point A to P2. The meter will first read close zero resistance. Then if the meter leads are left connected, the capacitors will slowly charge toward the supply voltage in the ohmmeter. The charging time constant is long because of the large values of C1 and C2. Therefore the measured resistance will gradually increase. The resistance may finally measure 1 MΩ or higher. A brief capacitor charging indication is evidence that C1 and C2 are not short-circuited or open.

NOTE 1: An ohmmeter check is not a conclusive test of a leaky capacitor because the ohmmeter voltage is relatively low. The capacitor may charge on an ohmmeter test but break down when rated Voltage is applied. A dynamic test of a capacitor is to test for dc voltage at P1 and at A with reference to P2. If the voltage is lower than normal and the ripple is excessive, one or both capacitors may be defective. Unhook one lead of a suspected leaky capacitor and replace with a good one. If the circuit functions properly, the defect is in the original capacitor.

NOTE 2: The forward and back resistances of a rectifier diode are measured by placing the ohmmeter leads across the diode and reading the resistance, then reversing the leads across the diode and again reading the resistance. The forward resistance (RF) should be relatively low and the back resistance (RR) very high. If RF and RR are close in value, the diode is defective.

TROUBLESHOOTING A POWER SUPPLY:

In troubleshooting an electronic device defects may sometimes be traced to the power supply. Thus, in **(Fig.6- 1)**, if the dc output voltage VP1G and VP2G are lower than normal, or if the ripple voltage at A, P1 and P2 are higher than normal, the trouble may be in the power-supply circuit, or in the load, for a large increase in load current can give these indications.

A first step in the troubleshooting process is to isolate the trouble to the load or to the supply by disconnecting the load from the supply. If the measured dc voltage at P1 and P2 are now higher than the rated V + or V - voltages under load, and if the ripple voltage at P1 or P2 is appreciably lower than the rated ripple under load, the trouble is in the load circuit.

However, if the voltages VPIG or VP2G without load are still low, and/or the ripple is still higher than normal, the trouble is in the power supply.

Troubleshooting the supply requires measuring both the dc voltages and the ripple voltages at P1, P2, and A with respect to ground. The results of these measurements may give a clue as to the trouble.

NO V + OR V – VOLTAGE:

If VPIG or VP2G = 0 V, the trouble may be due to defects in any of the following components: (a) open line cord or defective plug, (b) open fuse, (c) open switch, (d) open or short-circuited transformer winding, (e) defective D1 and D2, (f) short-circuited C1, (g) short-circuited C2, (h) open RC, (1) short-circuited RBI or RB2 (very unlikely). The problem then is to find the defective component and replace it with a known good one. This may involve voltage measurements, resistance measurements, and parts substitution.

If VP1G or VP2G measures 0 V, the next check is to measure the dc voltage VAP2. If there is voltage, the trouble is a short-circuited C2 or an open RC. A resistance check of these components will determine the trouble.

If VAP2 also measures 0 V dc, the trouble may be a short-circuited C1. However, before resistance-checking this component, another voltage check is indicated. Measure the ac voltage across the secondary of T1. It is possible to eliminate four of the components with this one check. If the ac voltage across the secondary is normal, then the line cord, fuse, switch, and power transformer are okay.

If there is no ac voltage across the secondary, remove the power plug from the ac outlet and measure the ac voltage at the outlet. If that is normal, proceed as follows. Connect an ohmmeter across the two hot prongs of the power plug. Close the switch. If the meter indicates continuity in the circuit (about 1 to 2 Ω), then the power plug, line cord, switch, fuse, and primary of the transformer are okay. If the meter shows infinite resistance, then it is necessary to make a continuity check of the plug and each wire in the line cord, fuse, switch, and primary of T1. One of these components will be open and should be replaced.

If the fuse is open, it may be because of a temporary overload or trouble in another circuit component. The simplest test is to replace the fuse and apply power to the circuit. If the fuse blows again, the trouble is elsewhere.

If all components from the line cord through the primary of T1 are okay, the trouble is an open secondary in T1. Check for continuity in the secondary to confirm this conclusion.

NOTE: A short-circuited transformer winding would also give no or low ac voltage across the secondary, but in that case there would be such an increase in ac current that the fuse would also blow.

Now assume that there is ac voltage across the secondary winding but that VP1G, VP2G, and VAG all measure 0 V dc. The trouble then may be a short- circuited C1 or open rectifiers D1 and (Note that if only one rectifier were open, there would still be dc voltage at A, F1, and F2, though the voltage would be lower than normal.) One other possibility is an open center tap on the secondary of the transformer or open wiring from the center tap to point P2. The defective

Component or the open lead from the center tap to point P2 may be found by resistance measurements.

As a final check the connections and wiring between components should be checked for continuity.

LOW V + OR V - HIGH RIPPLE:

An increase in load current or leaky electrolytic capacitors are the usual reasons for low output V and high ripple. Of course, as we noted previously, an open D1 or D2 can also cause this problem.

Oscilloscope checks across P1G and P2G (Fig. 6-1) will indicate not only the amplitude of ripple voltage but also the frequency of the ripple. The frequency should be 120 Hz for a full-wave rectifier. If it is 60 Hz, then either D1 or D2 is defective. These can be checked by determining their forward resistances. When the defective rectifier is replaced, the dc voltage and ripple levels should return to normal.

The usual cause for low V + or V - and high ripple is an open or leaky C1 or C2. The simplest procedure is to replace these capacitors, one at a time, with good capacitors until both dc voltage and ripple levels are restored to normal.

PROCEDURE

MATERIALS REQUIRED:

- Power supply: 220 -V rms 50-Hz source
- Equipment: Oscilloscope; EVM or VOM
- Resistors: 100-Ω, two 1200-Ω, 2700-Ω -1/2W; two 125-Ω, 2-W.
- Capacitors: Two 100-µ F 50-V; two 25-µ F 50-V
- Solid-state rectifiers: Two 1N4007 or equivalent
- Miscellaneous: Power transformer T1, 220-V primary, 26.8 -V 1-A center-tapped secondary; SPST switch; fused line cord

FULL-WAVE SUPPLY FOR V+ AND V-:

1. Connect the circuit of **Fig. 7-1**. C1 = C2 = 100 µ F 50V; C3 = C4 = 25 µ F 50 V; D1 and D2 are 1N5625 silicon rectifiers; RC = 100Ω 1/2 W; RB1 = RB2 1200Ω 1 W; T1 is the transformer used in Experiment no 5.

2. Close S1. Measure and record in **Table 7-1** the no-load dc voltage from V + to ground, V - to ground, V + to V - and A to V -. Observe and measure with an oscilloscope the no-load ripple waveform, its frequency, and the peak-to-peak voltage of the ripple from V + to ground, V - to ground, V + to V -, and A to V -. Record the results in **Table 7-1**.

3. Connect two 125- loads from V + and V - to G and repeat the measurements in step 2. Record your results in **Table 7-1**.

4. Open S1. Remove the lead connecting the anode of D1 to the secondary winding of T1. The result is a half-wave rectifier circuit which supplies V + and V-. Disconnect the 125-Ω loads.

5. Close S1. Repeat steps 2 and 3 and record the results in **Table 7-2**.

TABLE 7-1 FULL-WAVE V+ AND V- SUPPLY

Point	Load, Ω	DC, V	Ripple		
			Waveform	Frequency, Hz	V p-p
V + to G	No				
V + to G	250				
V − to G	No				
V − to G	250				
V + to V −	No				
V + to V −	250				
A to V −	No				
A to V −	250				

TABLE 7-2 HALF-WAVE V+ AND V- SUPPLY

Point	Load, Ω	DC, V	Ripple		
			Waveform	Frequency, Hz	V p-p
V + to G	No				
V + to G	250				
V − to G	No				
V − to G	250				
V + to V −	No				
V + to V −	250				
A to V −	No				
A to V −	250				

SUMMARY

1. The dc test points in a power supply with a π-type filter are the input to the filter (point A in **Fig. 6-1**) and the output from the filter (point P1). At each of these points, the dc voltage is measured with respect to point P_2.

2. In a filtered dc supply the dc input to the filter (V_{AP2} in **Fig. 6-1**). is higher than the dc output from the filter, V_{P1P2}. The relationship among V_{AP2}, V_{P1P2} and the voltage drop V_{AP1} across resistor RC (or filter choke) is $V_{AP2} = V_{P1P2} + V_{AP1}$.

3. The ripple voltage at the output of a power supply filter (V_{P1P2}) is always lower than the ripple voltage at the input to a π-type filter (V_{AP2}).

4. The ripple voltage on V + or V - under load is higher than the ripple voltage on V + or V - without load. A power supply must still furnish a relatively low ripple voltage on V + or V - under normal load.

5. AC test points in a transformer-fed power supply are (a) across the primary winding and (b) across the secondary winding. The ac voltage measured across the primary should be the line voltage. The ac voltage across the secondary is as specified by the manufacturer.

6. The dc voltage at the input to a π-type filter in a full-wave rectifier power supply is approximately one-half the peak-to-peak voltage across the secondary of the transformer.

7. In troubleshooting a power supply it may be necessary to measure the input and output dc voltages of the filter; ripple voltage at the same points; ac voltage across the primary and secondary of the transformer; resistance (with power off) at the output of and input to the filter; resistance and continuity of all the remaining components and wiring in the circuit.

8. In troubleshooting it is always desirable to isolate the trouble to part of a circuit, thus eliminating as “good” those components in that part of the circuit which tests out. For example, in the circuit of **Fig. 6-1**, if dc voltage and ripple checks across points AP_2 are normal, then all the components to the left of C1, including C1, are good. Similarly, if an ac voltage check across the secondary of T1 checks normal, then the ac input circuit components are good, with the possible exception of the tap on the secondary of the Transformer.