H740D power supply maintenance manual

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H740D power supply maintenance manual

digital equipment corporation · maynard, massachusetts

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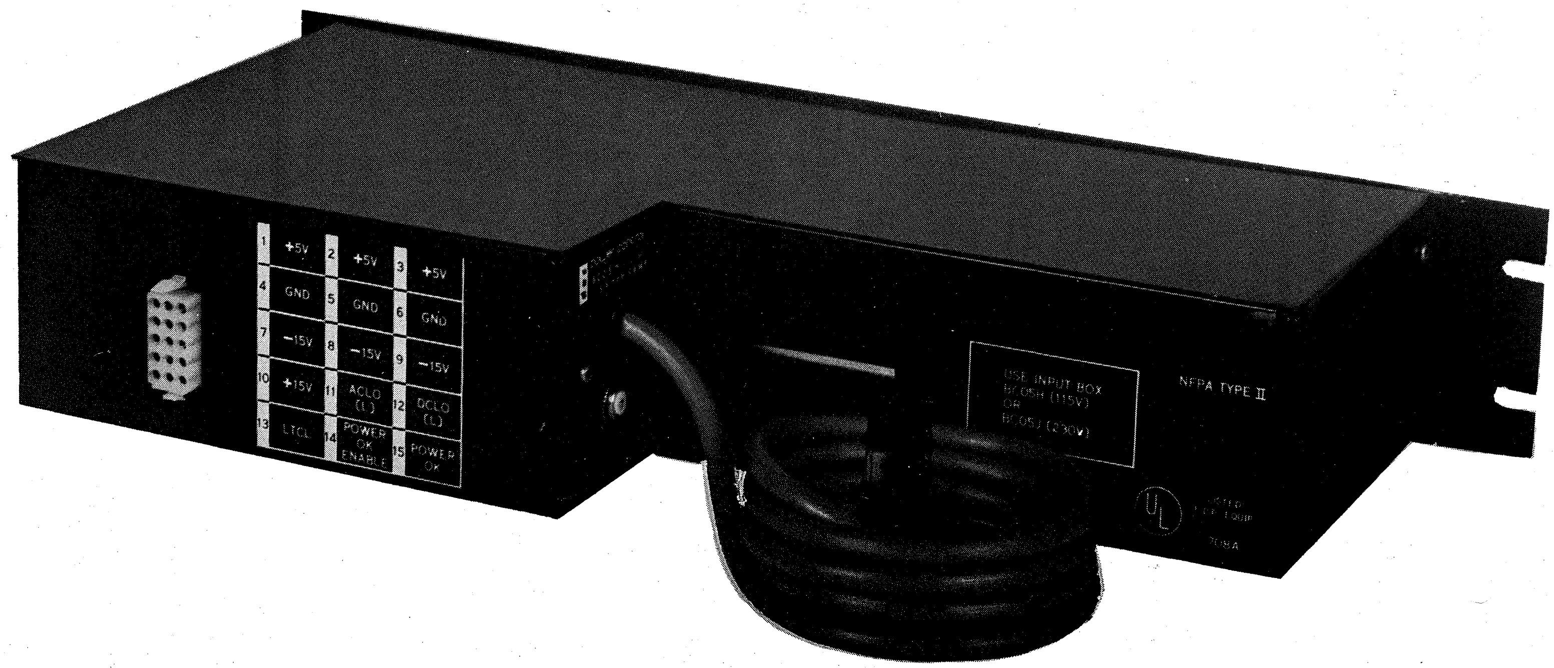


H740D Power Supply

CHAPTER 1
GENERAL INFORMATION

1.1 INTRODUCTION

This manual provides a complete description of the H740D Power Supply. Included are functional and circuit level descriptions, physical descriptions of the power supply and components, power supply specifications, installation information, and maintenance procedures.

1.2 GENERAL DESCRIPTION

The H740D Power Supply is a forced air-cooled unit that converts single-phase 115 V or 230 V nominal, 47–63 Hz line voltage to three regulated output voltages. The output voltages and their principal uses and characteristics are:

Voltage	Use	Characteristics
+15 V	Communication circuits	Series regulated and overcurrent protected
+5 V	IC logic	Switching regulated and overvoltage and overcurrent protected
-15 V	Core memory	Switching regulated and overvoltage and overcurrent protected

In addition, the H740D generates the following control signals: power fail early warning signals (AC LO L and DC LO L), an alternate AC LO L signal (PWR OK L), and a clock signal (LTC L).

The power supply is completely contained in the H740D chassis with one 3-wire input power cord (with plug) and one 15-socket Mate-N-Lok output connector, both accessible from the rear of the chassis.

The unit is equipped with overload and overtemperature protection devices. An input power circuit breaker removes power if input current is excessive (7 A @ 115 V, 4 A @ 230 V). A thermostat, mounted on the power supply heat sink, shuts down the power supply whenever heat sink temperature becomes excessive (100° C).

1.3 PHYSICAL DESCRIPTION

The power supply (Figure 1-1) consists of five subassemblies and two cable harnesses: power supply chassis, line set, transformer, dc regulator module, 3-inch fan, ac harness, and dc harness. Refer to engineering drawing D-UA-H740-D-0 for a cutaway view of the H740D.

NOTE

Although the line set is actually not part of the H740D Power Supply, a line set accompanies each H740D delivered and is mounted in the H740D chassis. Hence, for the convenience of the customer and Digital, the line set is treated as an integral part of the H740D Power Supply in this manual.

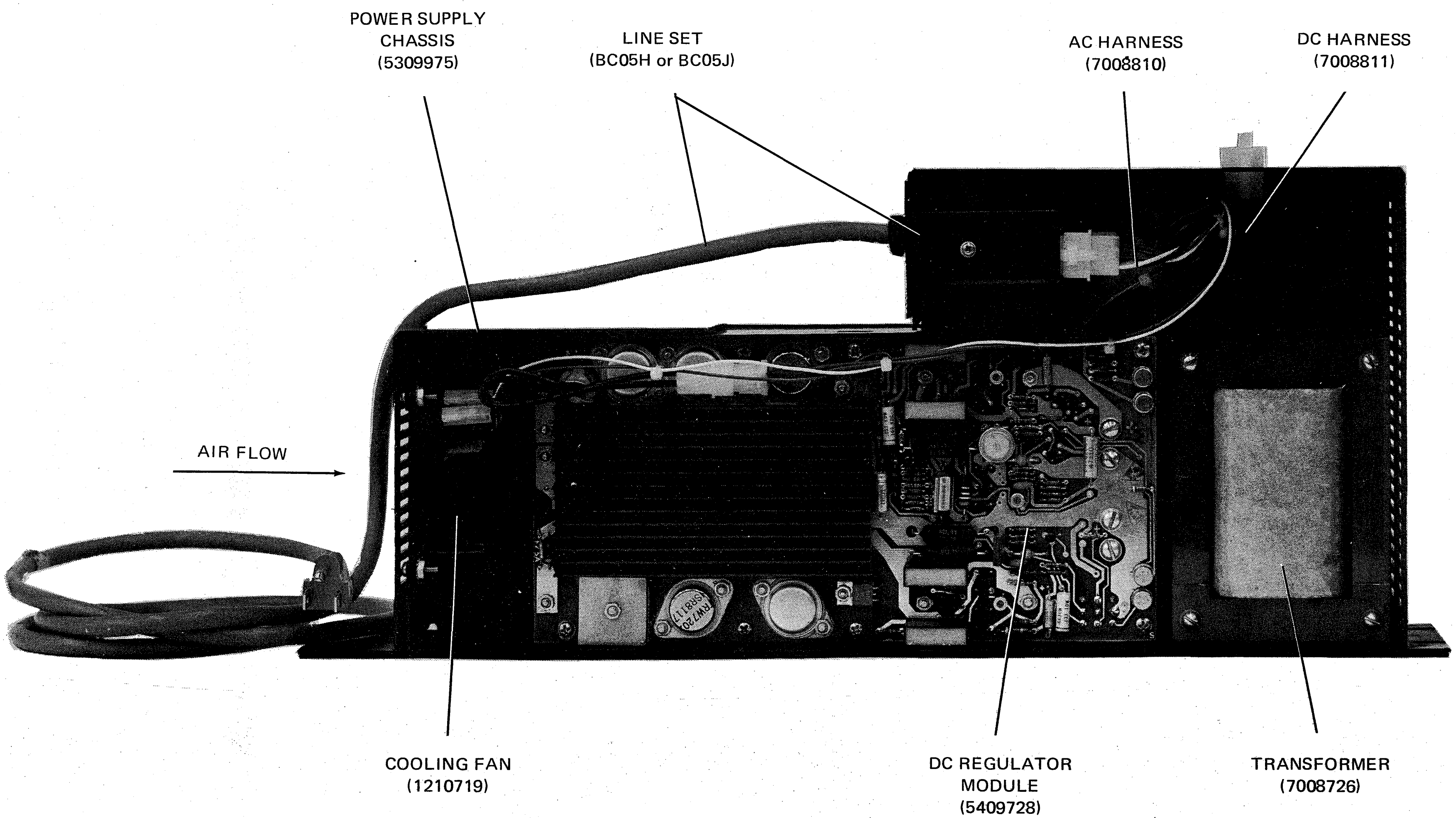


Figure 1-1 H740D Power Supply Components

1.3.1 Power Supply Chassis

The 5309975 chassis is a 3-1/2 in. high by 19 in. wide by 8 in. deep metal box that houses the power supply components. The box can be mounted in the rack or on the door using four bolts.

1.3.2 Line Set

The line set (Figure 1-2) adapts the power supply to the ac power source. Two different models are used: BC05H for 115 V operation and BC05J for 230 V operation. The line set is mounted in the rear of the power supply chassis by two 6-32 X 1/4 in. Phillips pan head screws. The unit consists of the H400 Power Control, a 6-ft line cord, and a 3-prong connector. The power control (engineering drawing D-UA-H400-0-0) consists of a single-pole thermal circuit breaker (7 A for 115 V operation, 4 A for 230 V operation), two RFI capacitors, and a 6-socket Mate-N-Lok connector that is jumpered for 115 V or 230 V operation. The power control components are mounted on a sheet metal bracket with a slide-on cover that is locked in place by a 6-32 X 1/4 in. Phillips pan head screw. The line cord, with a strain relief grommet, is installed through the sheet metal bracket. Two different types of ac plugs are attached to the line cord. The BC05H line set uses NEMA plug no. 5-15P. The BC05J line set uses NEMA plug no. 6-15P. (Refer to Figure 2-1 for complete plug specifications.)

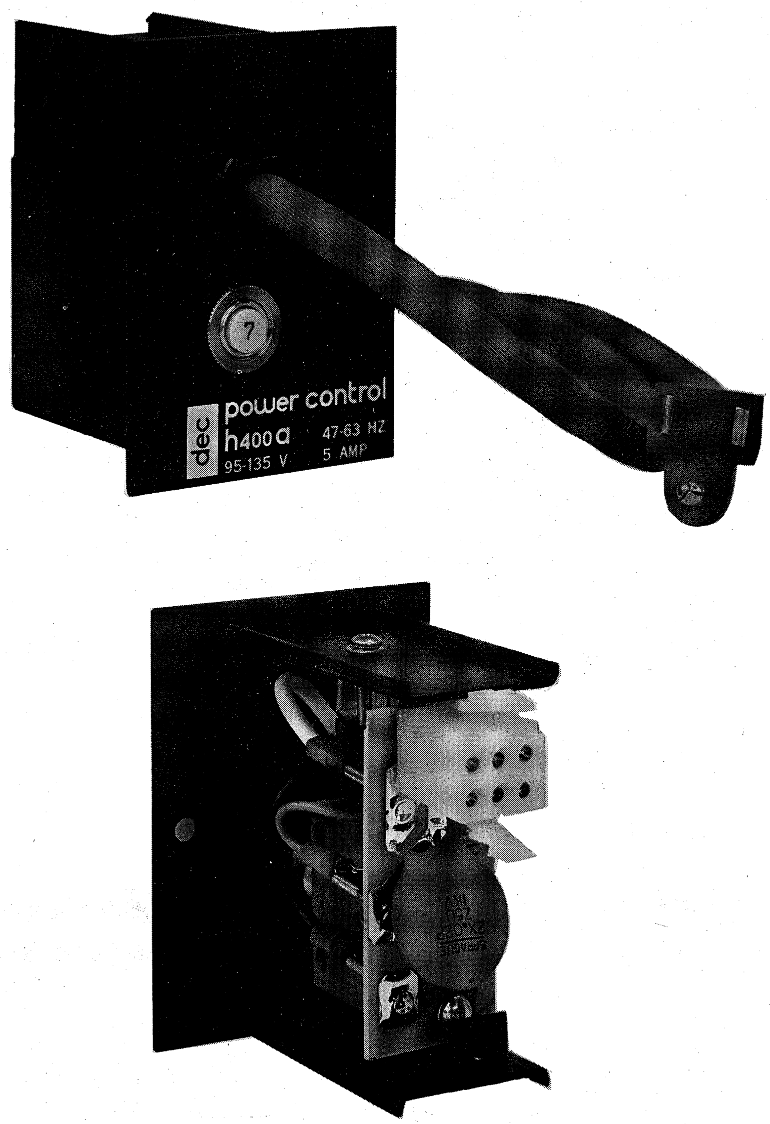


Figure 1-2 Line Set

With the power supply completely assembled, the line cord and the circuit breaker reset button are accessible from the rear of the power supply chassis. Note that the number on the reset button indicates the trip current of the circuit breaker.

NOTE
When ordering the H740D Power Supply, the line set must be ordered separately. Line set model BC05H is used for 115 V operation and model BC05J is used for 230 V operation.

1.3.3 Transformer Assembly

The 7008726 Transformer Assembly (Figure 1-3) receives input ac power from the line set via the ac cable harness and outputs 28 Vac directly to the dc regulator module. The assembly consists of power transformer T1, cabling, and Mate-N-Lok connectors P1 and J1. The transformer assembly is secured to the power supply chassis by four 8-32 KEPS nuts.

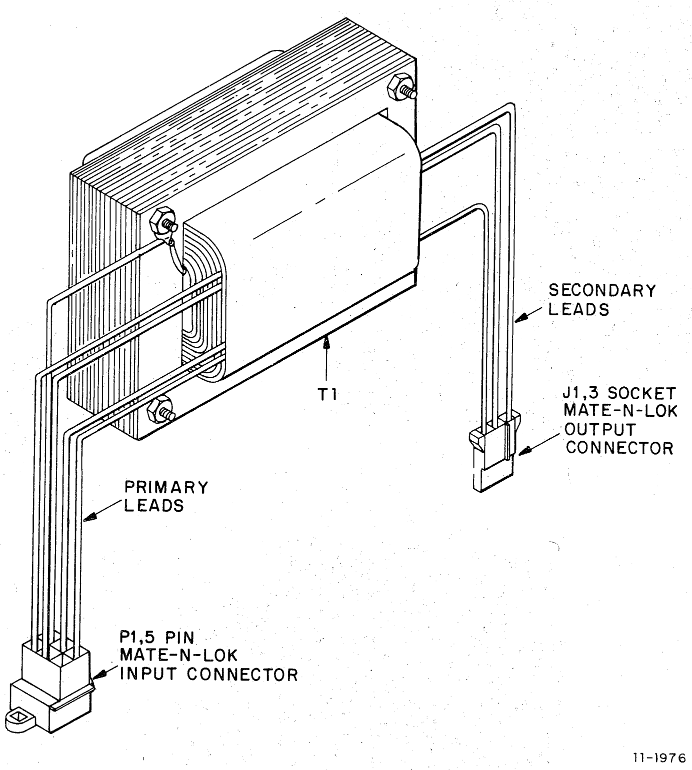
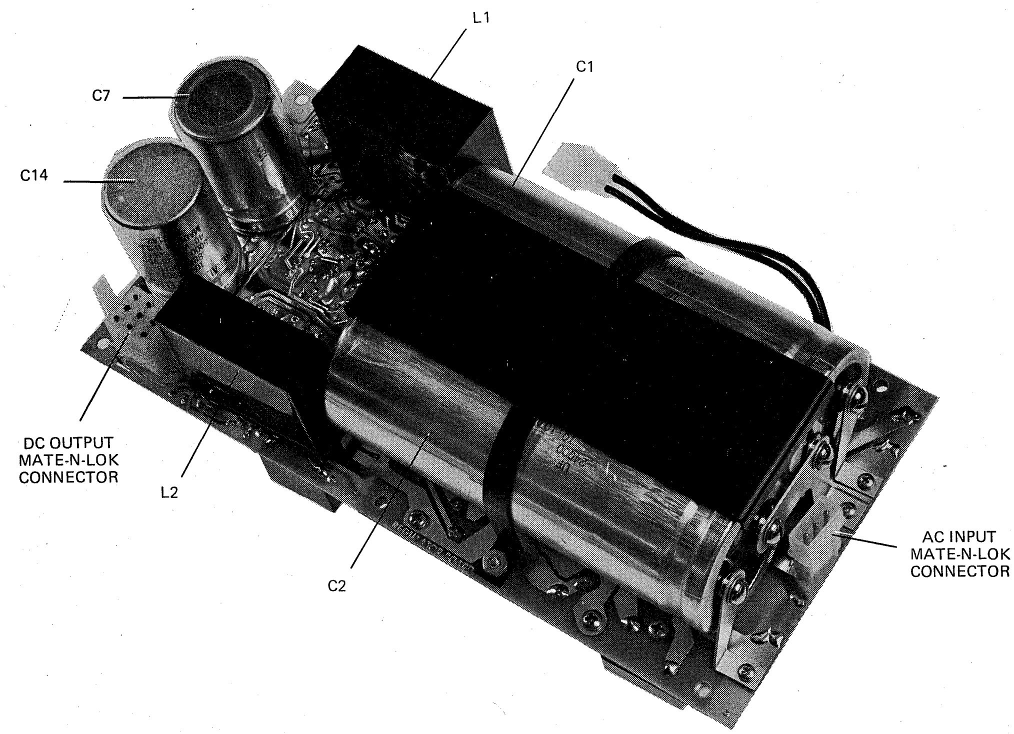


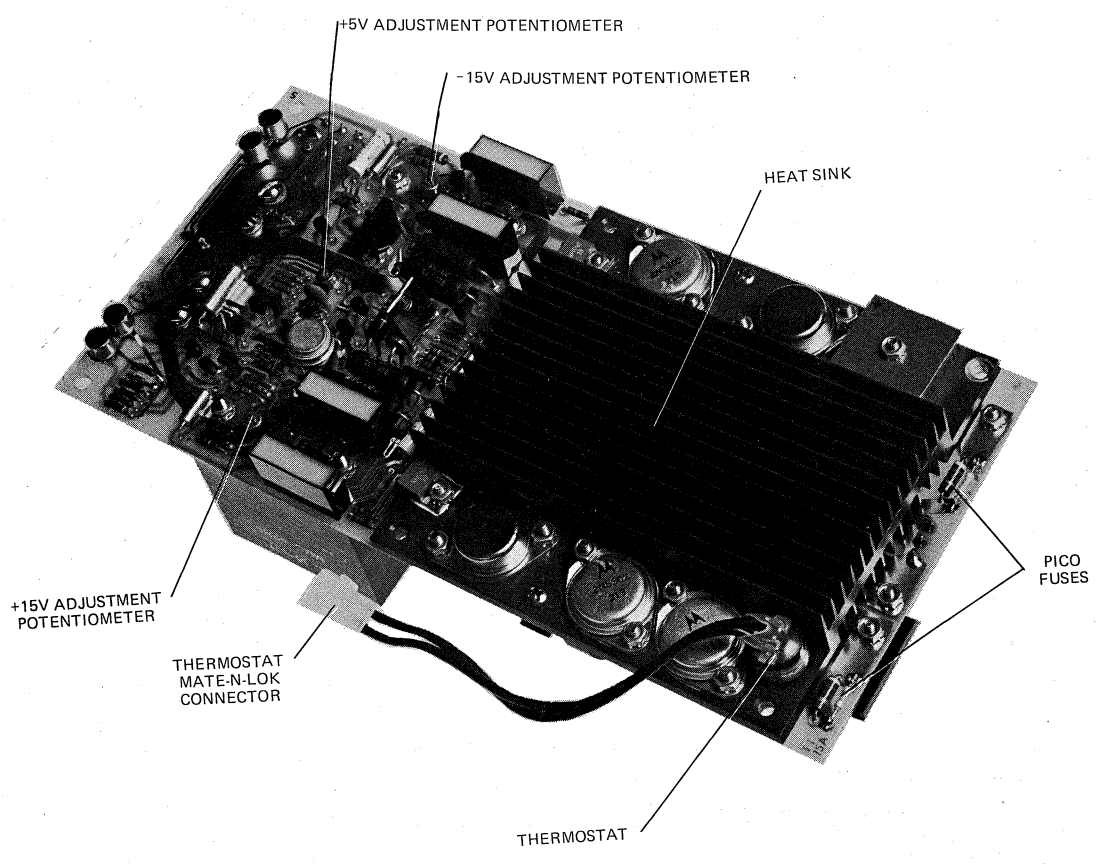
Figure 1-3 Transformer Assembly

1.3.4 DC Regulator Module

The 5409728 DC Regulator module (Figure 1-4) is a printed circuit assembly that is mounted to the power supply chassis and contains all the circuitry required to convert the transformer output to the three regulated dc outputs and to generate the control signal outputs. For overtemperature protection, a thermostat is mounted on the dc regulator module heat sink. The module is mounted to the power supply chassis by four 6-32 X 7/16 in. and two 6-32 X 1/4 in. Phillips pan head screws. Refer to engineering drawing E-IA-5409728-0-0 for a complete physical layout of the dc regulator module.



Top View



Bottom View

Figure 1-4 dc Regulator Module

The dc regulator module consists of many small components assembled into a compact package. The printed circuit board is approximately 5 in. X 10 in. with all points on the circuit accessible from the top. The heat sink is mounted on top of the printed circuit board. The power transistors and power rectifiers are bolted to shelves on the sides of the heat sink and make contact with the circuit board directly below via solder and screw connections. The thermostat is also attached to a heat sink side shelf. The 3-pin, ac input and 9-socket, dc output Mate-N-Lok connectors are soldered to opposite ends of the printed circuit board and are accessible from the bottom side.

The remaining portion of the top side of the printed circuit board is devoted to interconnecting and mounting the remaining circuitry. Three small output voltage adjustment potentiometers are mounted on the top side of the board as well as two small Pico (TM) fuses. Typically, these fast-acting fuses will blow only when a component fails, the +5 V or −15 V outputs are set too high, or the output is accidently connected to a higher voltage.

Other components are attached to the bottom side of the printed circuit board. The two input filter capacitors, C1 and C2, are bracketed to the bottom side of the board and are connected to the circuit via jumper tabs. The +5 V and −15 V output capacitors, C7 and C14, respectively, and inductors, L1 and L2, respectively, are also mounted to the bottom side of the board; the capacitors are attached by screws and the inductors are attached by nuts.

1.3.5 Cooling Fan

A 3-in. cooling fan is mounted on the left side of the power supply chassis. The fan draws air into the chassis and circulates it directly over the heat sink, capacitors, chokes, and transformer. The fan is driven by ac power from the line set via the ac cable harness. The fan runs constantly as long as power is applied to the power supply; the fan stops when an overtemperature condition causes the thermostat to open.

1.3.6 AC Harness

The ac harness (Figure 1-5) is located on the right side of the power supply chassis and interconnects the line set, transformer, thermostat, and fan. The harness consists of cabling, Mate-N-Lok connectors J1, J2, and J5, and fast-on tabs J3 and J4.

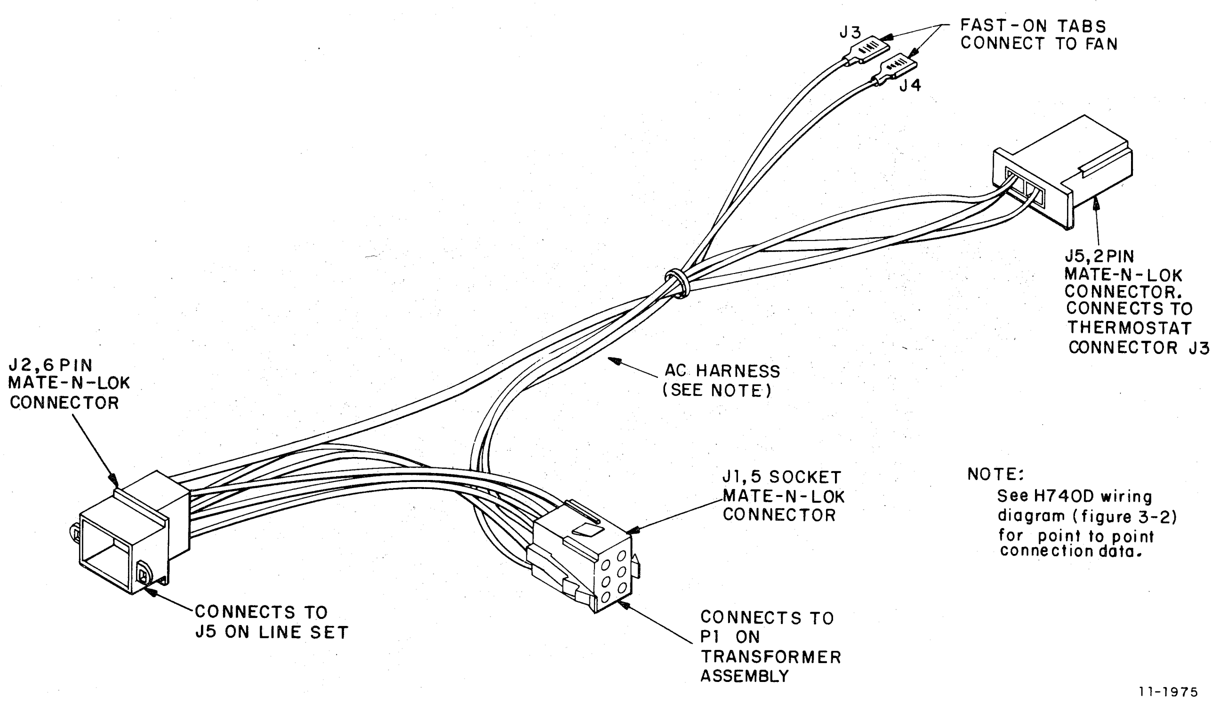


Figure 1-5 ac Harness

(TM) Pico is a trademark of Littlefuse Electrical Supply.

1.3.7 DC Harness

The dc harness (Figure 1-6) is also located on the right side of the power chassis, beneath the dc regulator module, and routes the power supply outputs from the dc regulator module to the rear of the chassis. The harness consists of cabling and Mate-N-Lok connectors J1 and J2.

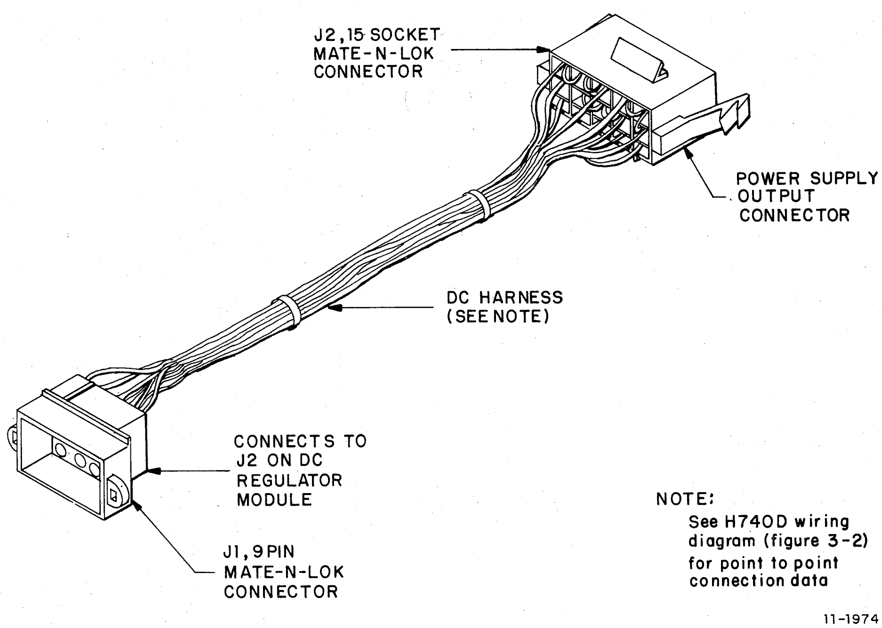


Figure 1-6 dc Harness

1.4 H740D SPECIFICATIONS

Tables 1-1, 1-2, and 1-3 list all the power supply specifications according to input, output, mechanical, and environmental specifications.

NOTE

The output parameters specified in Table 1-2 are measured at the 9-pin Mate-N-Lok connector J1 on the dc harness, which connects to output connector J2 on the dc regulator module. IR drops in the distribution wiring should be minimized to achieve the desired regulation at the load. Recommended distribution loss is 3 percent maximum. Regulation specified is with respect to the common ground terminal on output connector J2. Label on rear of H740D chassis identifies J2 outputs.

Table 1-1
Power Supply Input Specifications

Parameters	Specifications
*Input Voltage (1 phase, 2 wires, and ground)	95–135/190–270 V
Input Frequency	47–63 Hz
Input Current	5/2.5 A rms nominal
Input Power	325 W at full load
Inrush	80/40 A peak, 1 cycle
Rise Time of Output Voltages	30 ms max at full load, low line
Input Overvoltage Transient	180/360 V, 1 second 360/720 V, 1 ms
Storage After Line Failure	25 ms min, starting at low line, full load
Input Breaker (part of BC05 Line Set)	7A/4 A single-pole, manually reset, thermal
Thermostat Mounted on Heat Sink (opens transformer and fan power)	277 V, 7.2 A contacts Opens 98°–105° C Automatically resets 56°–69° C
Input Connections	Line cord on BC05 Line Set, length and plug type specified with BC05 (Paragraph 1.3.2)
Turn-On/Turn-Off	Application or removal of power
Hipot (input to chassis and output)	2.1 kV/dc, 60 seconds

*Input voltage selection, 115 V or 230 V, is made by specifying the appropriate Digital Model BC05 (Paragraph 1.3.2). All specifications are with respect to the BC05 input.

Table 1-2
Power Supply Output Specifications

Parameter	Specifications
+15 V	
Load Range	
Static	0–1 A
Dynamic	0–1 A
Max Bypass Capacitance in load for 30-ms turn-on	500 μF
Overload Protection	None
Current Limit @ 25° C	1.3–1.7 A (-6.2 mA/° C)
Backup Fuse	15 A (also used for +5 V)
Adjustment Range	±5% min
Regulation (all causes including line, load, ripple, noise, drift, ambient temperature)	±5%
+5 V	
Load Range	
Static	0–20 A
Dynamic #1	±5 A (within 0–20 A load range)
Dynamic #2	No load – full load
Max Bypass Capacitance in load for 30-ms turn-on	2000 μF
Overvoltage Crowbar (blows fuse)	5.7–6.8 V actuate (7 V absolute max output)
Current Limit at 25° C	24–29.4 A (-0.1 A/° C)
Backup Fuse (series with raw dc)	15 A
Adjustment Range	±5% min
Regulation	
Line	±0.5%
Static Load	3%
Dynamic Load #1	±2%
Dynamic Load #2	±10%
Ripple and Noise	4% peak-to-peak
1000 Hour Drift	±0.25%
Temperature (0–50° C)	±1%

Table 1-2 (Cont)
Power Supply Output Specifications

Parameter	Specifications
-15 V	
Load Range	
Static	0–7 A
Dynamic #1	ΔI = 5 A (0.5 A/μs)
Dynamic #2	No load – full load (0.5 A/μs)
Max Bypass Capacitance in load for 30-ms turn-on	1000 μF
Overvoltage Crowbar (blows fuse)	17.4–20.5 V (22 V absolute max output)
Current Limit at 25° C	10–13.3 A (-0.03 A/° C)
Backup Fuse (series with raw dc)	5 A
Adjustment Range	±5% min
Regulation	
Line and Static Load	±1%
Dynamic Load #1	±2.5%
Dynamic Load #2	±3%
Ripple and Noise	3% peak-to-peak
1000 Hour Drift	±0.25%
Temperature (0–50° C)	±1%

BUS DC LO L and BUS AC LO L
Static Performance at Full Load
(for 230 V connection, double voltages below)

BUS DC LO L goes to high	74–80 Vac line voltage
BUS AC LO L goes to high	8–11 Vac above voltage at which BUS DC LO L goes to high
BUS AC LO L drops to low	80–86 Vac line voltage
BUS DC LO L drops to low	7–10 Vac below voltage at which BUS AC LO drops to low
Hysteresis (contained in above specifications)	3–4 Vac
Output voltages still good	70 Vac line voltage

Table 1-2 (Cont)
Power Supply Output Specifications

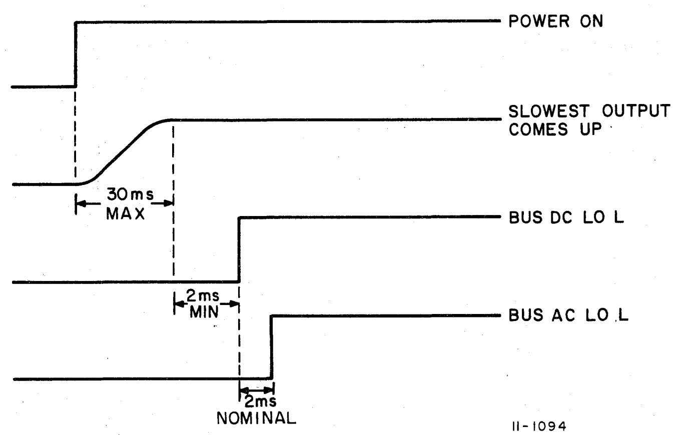
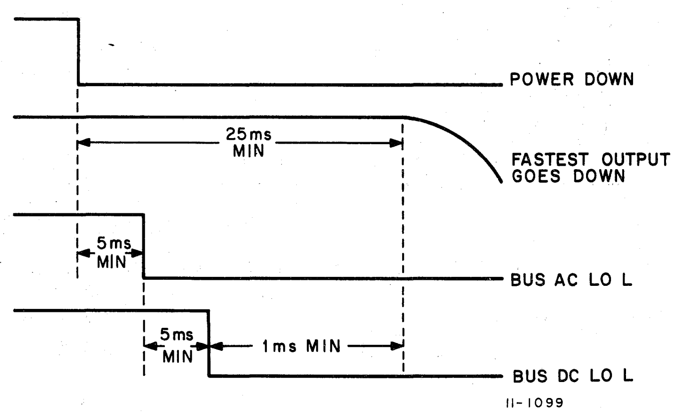
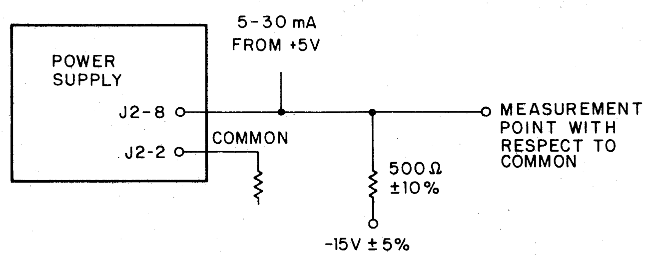
Parameter	Specifications
BUS DC LO L and BUS AC LO L (Cont)	
Dynamic Performance	
Worst case on power-up is high line, full load	
Worst case on power-down is low line, full load	
Output Characteristics	
Open Collector	50 mA sinking capability +0.4 V max offset
Pull-Up Voltage on Unibus	5 V nominal, 180 Ω impedance
Rise and Fall Times	1 μs max Outputs shall remain in 0 state subsequent to power failure until power is restored despite Unibus pull-up voltages remaining

Table 1-2 (Cont)
Power Supply Output Specifications

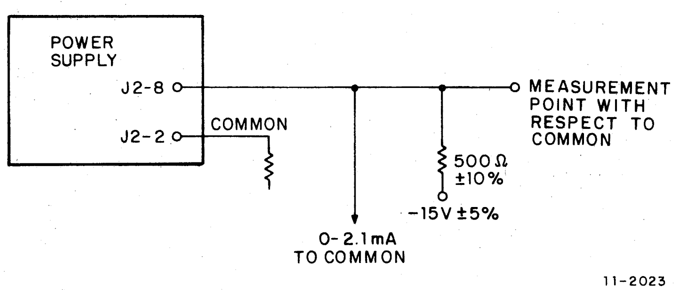
Parameter	Specifications
POWER OK L	

If output connector pin J2–11 is jumpered to pin J2–14, an alternate AC LO L signal is available on pin J2–15. The static and dynamic performance characteristics are the same as stated above for AC LO L.

Load Impedance
Low State



High State



Parameter	Specifications
Output Impedance	105 Ω max
Open Circuit Voltage	+3.5 to +5.5 V (True) -1 to +0.5 V (False)
Rise and Fall Times	1 μs max
Load May Be Active	0 to +5.25 V max
Short Circuit Current (to ground)	165 mA max

Table 1-3
Mechanical and Environmental Specifications

Parameter	Specifications
Weight	
DC Regulator	7 lb approximate
Power Chassis Assembly including DC Regulator Module	24 lb approximate
Dimensions	3.5 in. height 19 in. width 8 in. depth
Cooling Means	Integral 3 in. fan (cover required over heat sink to plenum air)
Minimum Cooling Requirements	375 CFM through heat sink 250 CFM over caps, chokes, and transformer
Rated Heat Sink Temperature	95° C max
Shock, Nonoperating	40 G (duration 30 ms) 1/2 sine in each of six orientations
Vibration, Nonoperating	1.89 G rms average, 8 G peak; varying from 10 to 50 Hz, 8 dB/octave roll-off 50–200 Hz; each of six directions
Ambient Temperature	0° to +60° C operating -40° to 71° C storage
Relative Humidity	95% max (without condensation)
Altitude	10 K ft

CHAPTER 2
INSTALLATION

2.1 INTRODUCTION

The H740D Power Supply is completely contained in an enclosed box with only the ac line cord, the circuit breaker reset button, and the dc output connector accessible from without. Before ordering the H740D, the customer should consider the dc voltage levels and power requirements of the device or devices that are to be powered by the H740D. The customer should then consider the space, environment, power, and cable requirements of the H740D. The following paragraphs provide that information, as well as information on inspecting, mounting, connecting, and turning on the power supply.

2.2 POWER SUPPLY CONFIGURATION

The H740D is available in 115 V and 230 V configurations. The only difference between the two configurations is the type of line set installed. The BC05H Line Set is installed for 115 V operation, the BC05J Line Set is installed for 230 V operation. The customer must specify the line set desired when ordering the H740D.

2.2.1 Space Requirements

The H740D only occupies a space 3-1/2 in. high X 19 in. wide X 8 in. deep.

2.2.2 Environmental Requirements

H740D environmental requirements are listed in Table 1-3.

2.2.3 Power Requirements

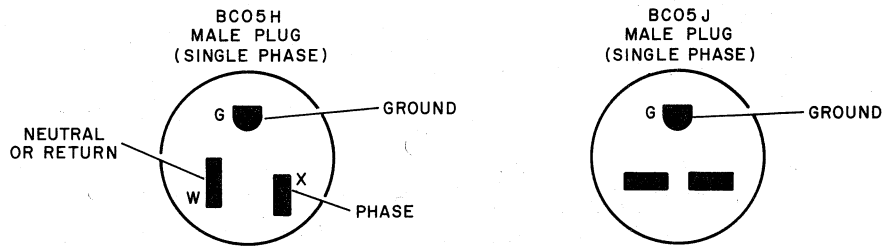
The H740D ac input power source must be capable of providing at least 325 W of 47–63 Hz ac power. The power supply is equipped with a 6-ft, 3-wire line cord and a 3-prong plug. The prime power ac input wall receptacle must be the same type as the line cord plug. Refer to Figure 2-1 for H740D connector specifications.

2.2.4 Cable Requirements

The H740D outputs are available at a 15-socket Mate-N-Lok connector accessible from the rear of the power supply chassis. Due to the varying requirements of different customers with respect to outputs used and cable lengths required, the fabrication of an H740D interconnecting cable harness is left to the customer.

2.3 INSTALLATION PROCEDURES

The procedures presented in the following paragraphs are provided to assist in inspecting, mounting, connecting, and turning on the H740D Power Supply.



CONNECTOR SPECIFICATIONS

MODEL NUMBER	NEMA* CONFIGURATION	DESCRIPTION	POLES	WIRES	PLUG		RECEPTACLE	
					DEC PART NO.	HUBBEL	DEC PART NO.	HUBBEL
BC05H	5-15	115V, 15AMP	2	3	90-08938	5266-C	12-05351	5262
BC05J	6-15	230V, 15 AMP	2	3	90-08853	5665-C	12-11204	5662

*ADD P SUFFIX FOR PLUG
ADD R SUFFIX FOR RECEPTACLE

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Figure 2-1 H740D Connectors

2.3.1 Inspection

Before installing the H740D, inspect it and report any damage to the local Digital Sales Office. Inspect as follows:

1. Inspect the chassis, line cord, and plug for damage.
2. Remove the top cover and inspect for loose or broken components, fan damage, cable damage, and loose nuts, bolts, screws, etc.
3. Inspect for proper seating of fuses and power connectors.

2.3.2 Mounting the H740D

The H740D can be mounted easily in any 19-in. equipment rack. Four bolts are used to attach the unit to the rack; it can be mounted within the rack or on the door. The H740D comes equipped with a 6-ft ac power cord. If a longer cord is desired, the desired length must be stipulated when ordering the power supply.

CAUTION
Ensure that the H740D is installed so as not to obstruct the cooling fan intake vent as this may cause overheating.

2.3.3 AC Power Connection

The H740D is equipped with a 3-prong connector which, when inserted into a properly wired outlet, grounds the power supply chassis. Due to normal leakage current from the power supply flowing into metal parts of the chassis, it is unsafe to operate the H740D unless the chassis is grounded properly. If the integrity of the ground circuit is questionable, the user is advised to measure the potential between the chassis and a known ground with an ac voltmeter.

2.3.4 Initial Power Turn-On

Before connecting any devices to the H740D dc outputs, perform the following procedure:

CAUTION

Verify that ac primary input power is compatible with the H400 Power Control Box installed in the H740D. Power requirements are indicated on the rear of the power supply chassis.

1. Plug in the ac power cord and check for proper dc voltages at the 15-socket Mate-N-Lok connector. Voltages should read as labeled on the rear of power supply chassis.

2. If any dc output voltages are incorrect, perform maintenance on the H740D before continuing with this procedure. Maintenance procedures are provided in Chapter 4.

3. Check cooling fan operation. Verify that the fan is moving freely and that air flow is in the proper direction (fan draws air into chassis).

4. Unplug ac power cord.

2.3.5 Connecting the H740D to the Device

Interconnect the H740D and the device in accordance with the following procedure:

1. Using the interconnecting cable harness (fabricated by the customer), connect the required power supply outputs to the device. Refer to the device maintenance manual to determine the dc voltages and control signals required for device operation.

   NOTE

   If the PWR OK L output is to be used as an alternate AC LO L signal, a jumper wire must be connected between pins 11 and 14 of the dc output connector on the rear of the power supply chassis.

2. Plug in the H740D ac power cord.

CHAPTER 3
PRINCIPLES OF OPERATION

3.1 INTRODUCTION

The power supply (Figure 3-1) can be divided functionally into five parts:

a. the line set, which adapts the power supply to 115 or 230 Vac input power and provides overload protection;

b. the thermostat, which provides overtemperature protection;

c. the fan, which provides forced air cooling;

d. the transformer, which steps the ac input voltage down to the level required by the dc regulator module;

e. the dc regulator module, which converts ac inputs to regulated dc outputs and provides power fail and clock outputs.

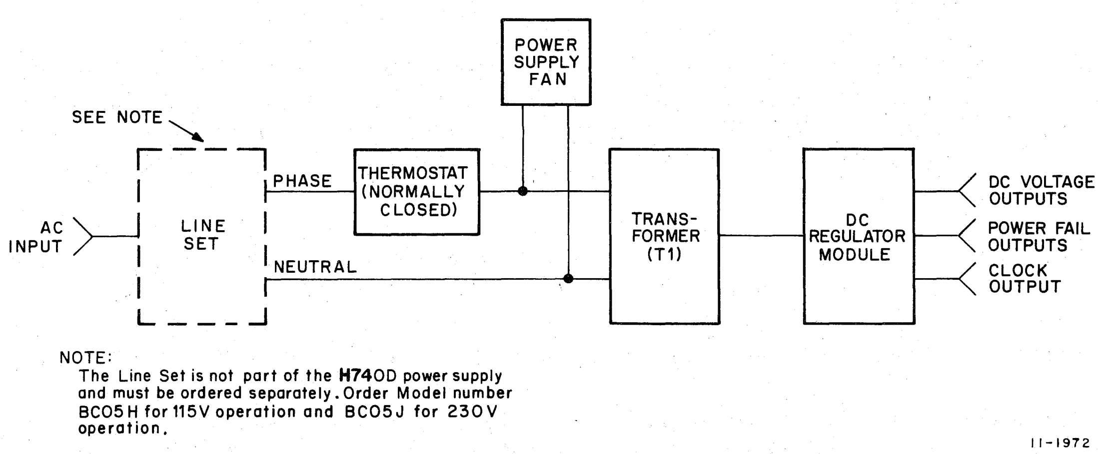


Figure 3-1 Power Supply Block Diagram

The following paragraphs provide detailed descriptions of the H740D components.

3.2 LINE SET

To adapt the power supply to 115 or 230 Vac input power, the line sets (BC05H for 115 V operation, BC05J for 230 V operation) use different jumper wire configurations on output connector J5 (see Figures 3-2, 3-3, and 3-4). The 115 V line set output connector is jumpered such that the two primary windings of transformer T1 are connected in parallel to the 115 Vac input; the 230 V line set output connector is jumpered such that the two primary windings of transformer T1 are connected in series to the 230 Vac input.

For overload protection, the line set contains a single-pole thermal circuit breaker. The circuit breaker trips when input current becomes excessive (7 A, @ 115 V, 4 A, @ 230 V) and is reset by pressing the reset button on the rear of the power supply chassis.

3.3 THERMOSTAT

For excessive heat protection, the power supply is equipped with a thermostat that is mounted on the heat sink (Figure 3-2). The thermostat opens one side of the primary power input circuit whenever the heat sink temperature rises to approximately 100° C, thereby removing power from the power supply and the cooling fan. The thermostat automatically resets at approximately 63° C.

3.4 COOLING FAN

The H740D uses a 3 in. fan (Figure 3-2) to circulate air over the heat sink, capacitors, chokes, and transformer. The fan operates continuously as long as the power supply is energized. If the thermostat opens, power is removed from the fan as well as the power supply. The fan forces air through the heat sink at a minimum rate of 375 linear feet per minute and over the capacitors, chokes, and transformers at a minimum rate of 250 linear feet per minute.

3.5 TRANSFORMER

The H740D uses a step-down transformer to reduce the 47 to 63 Hz line voltage to 28 Vac as required by the dc regulator module (Figure 3-2). The transformer has two primary windings and one secondary winding. As previously stated, jumper wires in the line set connect the primary windings in parallel for 115 V input and in series for 230 V input.

3.6 DC REGULATOR MODULE

A block diagram of the dc regulator module is shown in Figure 3-5. See engineering drawing D-CS-5409728-0-1 for the complete circuit schematic. The center-tapped output of power transformer T1 is applied to the rectifier and filter circuits. The rectifier circuits produce ±39 V nominal raw dc voltages which are unregulated but well filtered by the input storage capacitor.

The +39 Vdc is used to power two regulators: the +15 V regulator and the +5 V regulator. The +15 V regulator is a simple series regulator; the +5 V regulator is a higher powered, more efficient, switching regulator. Both regulators incorporate current limiting circuitry. The +5 V output is also protected against overvoltage by a crowbar circuit that limits the output to under 7 V; before the output gets to this value the crowbar circuit blows the fuse in the output circuit of the rectifier.

The −39 Vdc is used by the −15 V circuit, which is similar in operation to the +5 V regulator circuit. The −15 V crowbar circuit limits the output to −22 V.

The Clock signal (LTC L) is generated by a simple Zener clipper that is fed from the transformer secondary.

The AC LO L and DC LO L signals are used to warn the devices powered by the H740D and other designated devices of imminent power failure. Basically the transformer secondary voltage is detected and used to generate two timed TTL-compatible open-collector signals, which are used for power fail functions. These signals are Unibus (PDP-11 bus) compatible.

The PWR OK L signal is used by some devices as an alternate to the AC LO L signal. The PWR OK L circuit monitors the AC LO L output. When the AC LO L output is asserted, PWR OK L is asserted. However, AC LO L asserted places a ground directly on the output while PWR OK L asserted places a 100 Ω resistor tied to ground on the output. Some devices may have power fail circuits which would be damaged if a ground were applied to them. These devices would use the PWR OK L output. Note that AC LO L must be jumpered to the emitter follower if the PWR OK L output is to be used. This signal is Omnibus (PDP-8 bus) compatible.

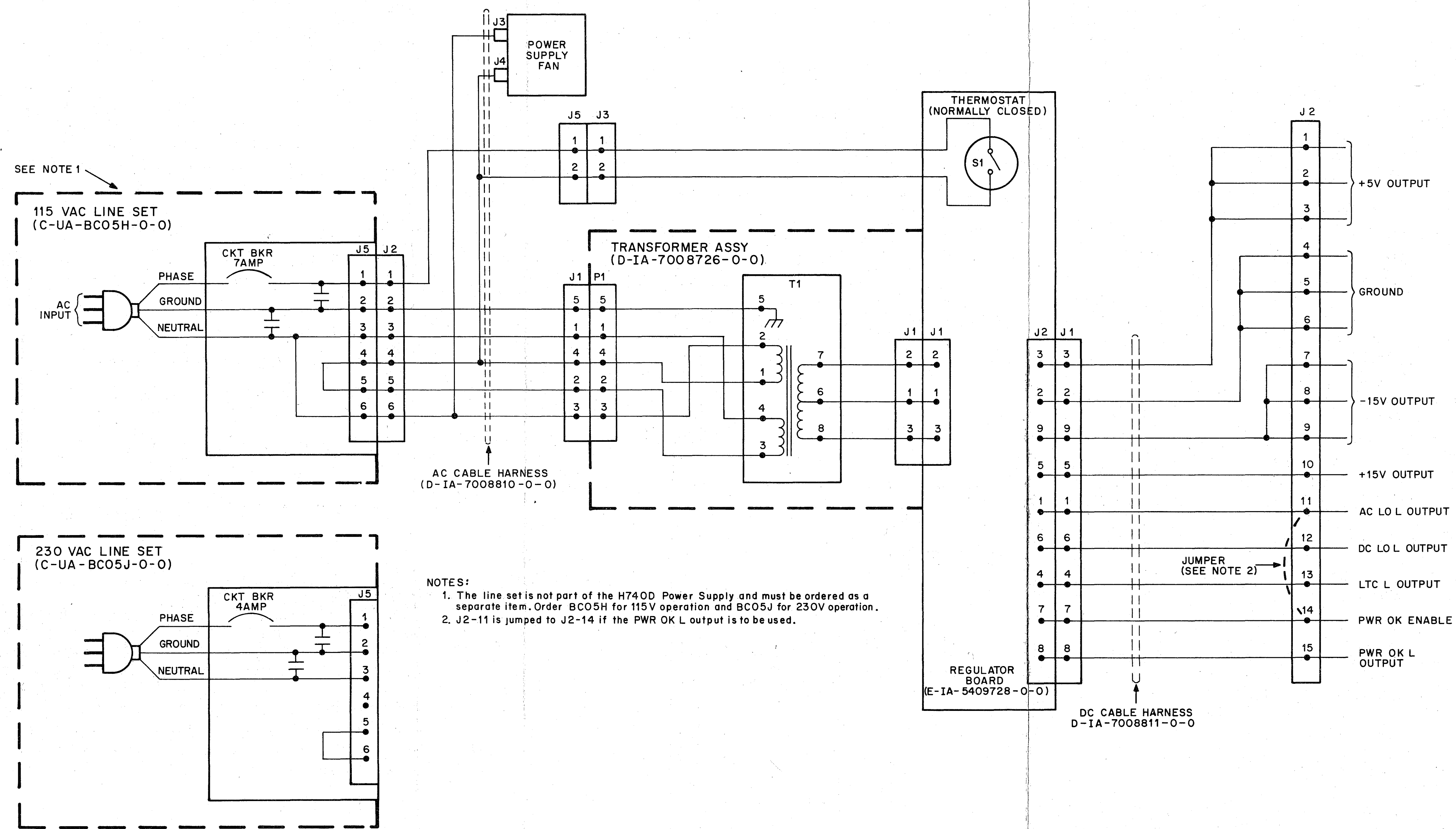


Figure 3-2 H740D Power Supply, Wiring Diagram

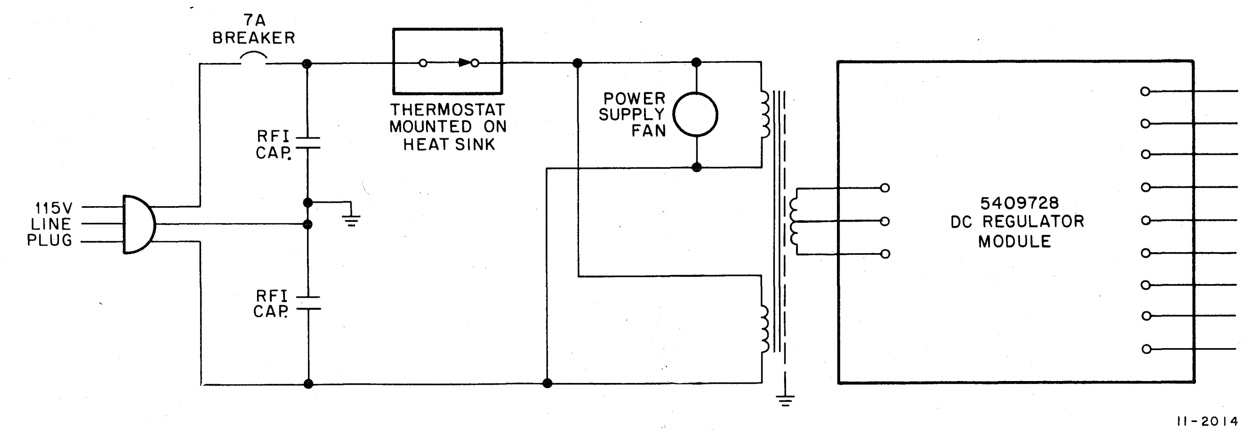


Figure 3-3 115 V Connection, Simplified Schematic Diagram

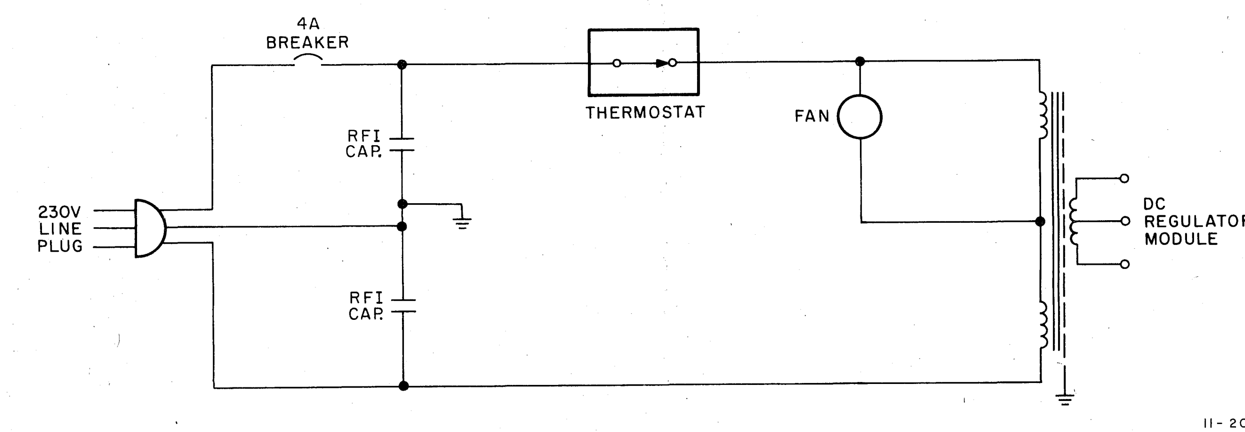


Figure 3-4 230 V Connection, Simplified Schematic Diagram

3.6.1 Generation of Raw DC Voltages

As stated, the center tapped transformer secondary voltage is rectified and filtered prior to being fed to the three dc regulators. The circuitry which accomplishes this is shown in Figure 3-6. Bridge rectifier D14 rectifies the ac and capacitors C1 and C2 filter the dc and maintain voltage for at least 25 ms when the input power is turned off or fails. Fuses F1 and F2 protect the regulator and load during fault conditions. Normally, the fuses will not blow when a regulator output is shorted because the three outputs are electronically overcurrent protected. However, the appropriate fuse will blow in the event of a +5 V or −15 V overvoltage crowbar or a failure in one of the overcurrent circuits. The resistors across the fuses provide a slow discharge (100–150 seconds) when power is turned off after a fuse blows. The capacitors are placed ahead of the fuse to limit the energy in the event of a fault and thus better protect the outputs.

3.6.2 LTC L Circuit

The Clock signal (Figure 3-6) is generated by a Zener clipper circuit. The output waveform is a square (clipped sine) wave at line frequency. For the positive half of the output sine wave, D13, clips at about +3.9 V; for the negative half, D13 clips at its forward voltage of −0.7 V.

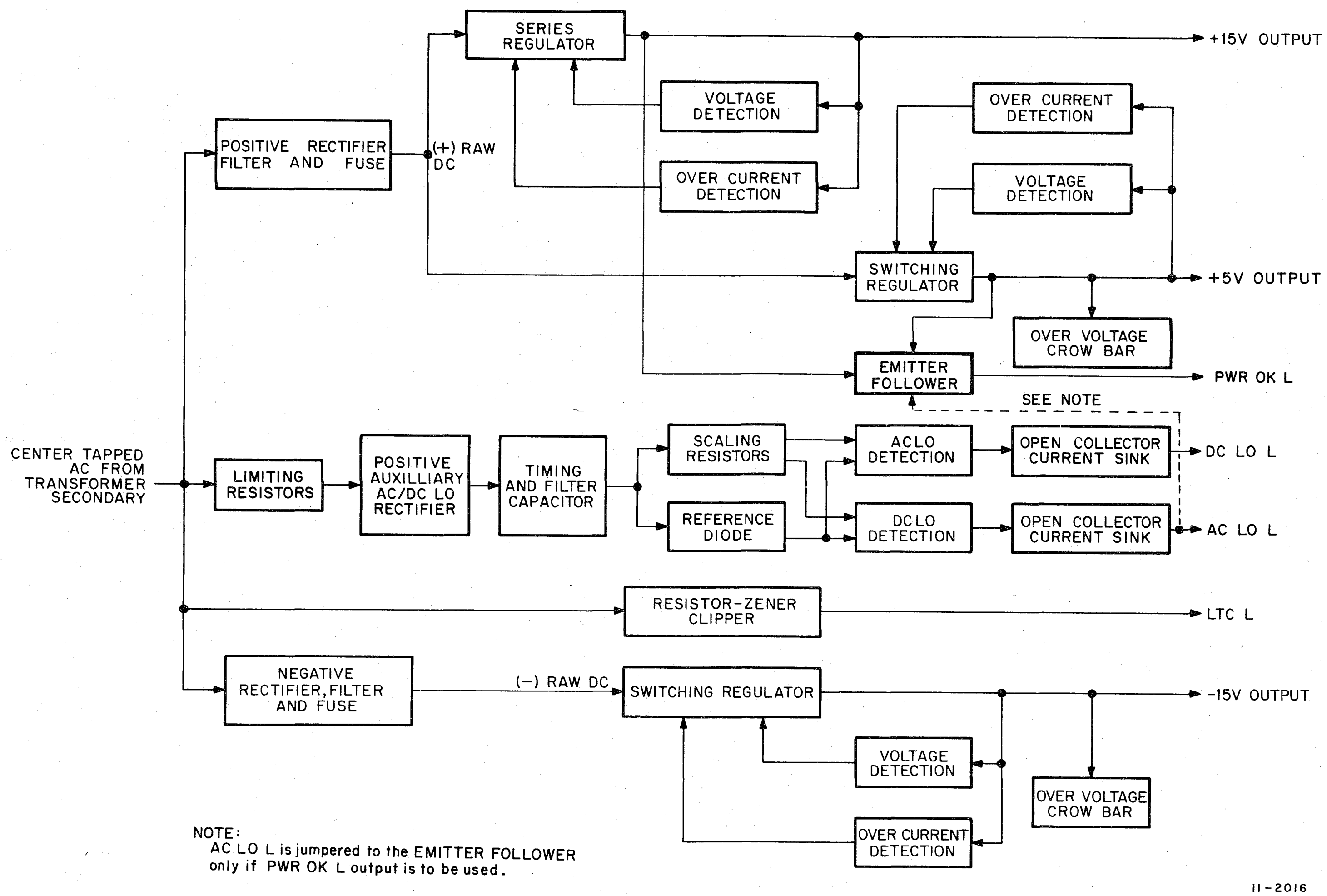


Figure 3-5 dc Regulator Module, Block Diagram

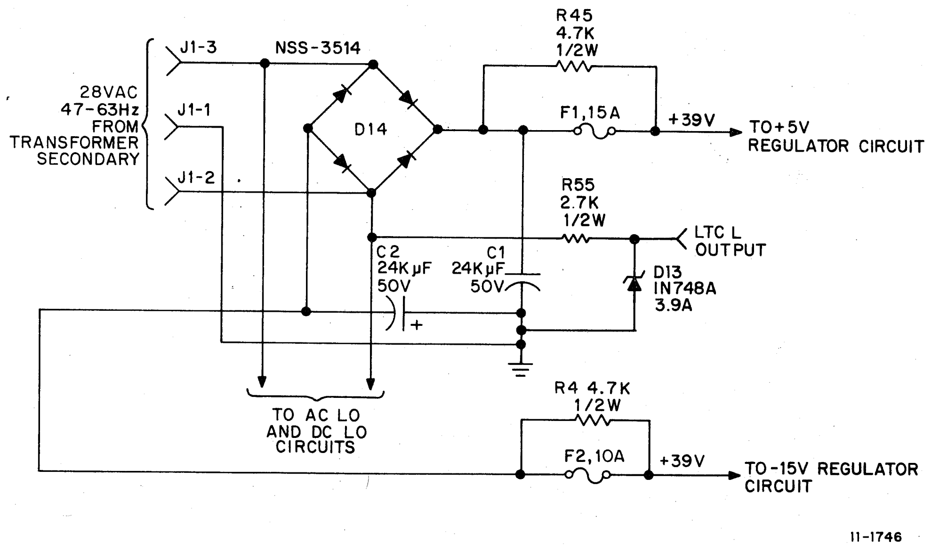


Figure 3-6 Rectifier and LTC L Circuits

3.6.3 AC LO L and DC LO L Circuits

The circuitry shown in Figure 3-7 is employed to generate the timed Unibus power status signals AC LO L and DC LO L. These signals are used for power fail functions. The transformer secondary voltage is rectified by D1 and D2 and filtered by C9 and R1, R14. Circuit parameters are chosen so that the voltage across C9 rises slower than the three regulated output voltages on power-up and decays faster than the three regulated output voltages on power-down. Two differential amplifier circuits are used to detect power status: Q17, Q18 generate DC LO L; and Q15, Q16 generate AC LO L. The differential amplifiers share a common reference Zener diode D3, which is fed approximately 1 mA by R3. As C9 charges subsequent to power-up, first Q17, Q18 and then Q15, Q16 change state; the reverse is true during power-down. When C9 starts to charge, Q17 and Q16 are on and Q15 and Q18 are not conducting. As C9 charges further, Q18 starts to conduct into R7 and raises the voltage on the cathode of D3. This acts as positive feedback and snaps Q17 off and Q18 on more solidly. A few milliseconds later, the voltage across C9 has risen sufficiently for the same process to take place in differential amplifier Q15, Q16.

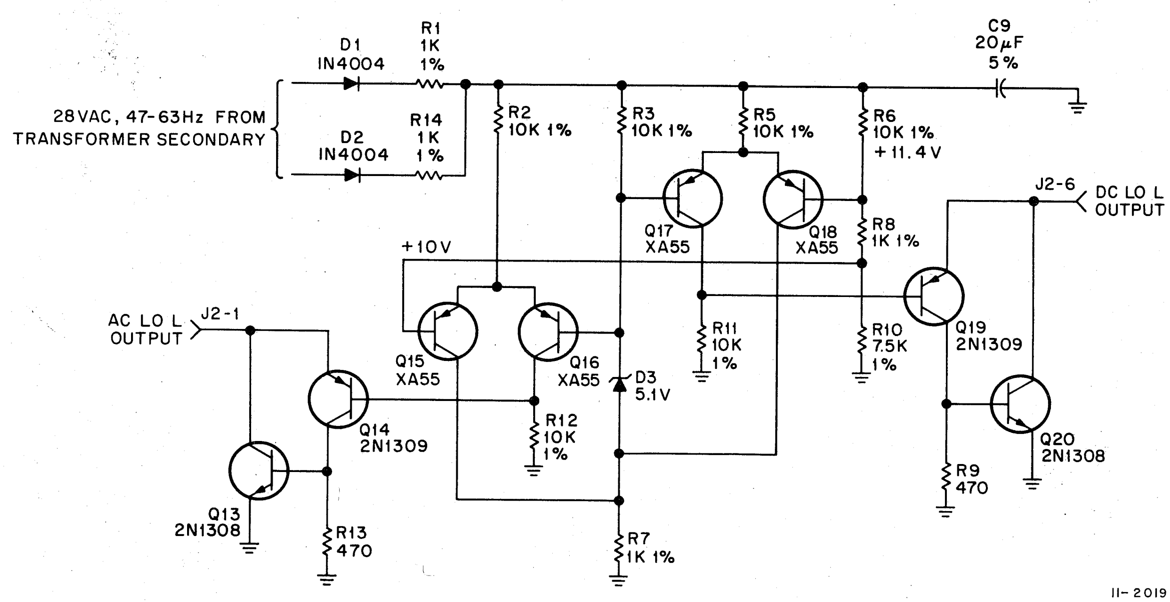


Figure 3-7 AC LO L and DC LO L Circuits

The status of each differential amplifier is followed by the germanium transistor open-collector output stages Q19, Q20 for DC LO L and Q13, Q14 for AC LO L. These stages clamp the Unibus at about +0.4 V until the differential amplifier circuits sequentially signal them across R11 and R12 that power is up. The outputs then rise to about +5 V as dictated by the Unibus loading and pull-up termination resistors.

The sequence is as follows:

power up → then BUS DC LO L = 0 → then BUS AC LO L = 0
0 = high (+3 V)

power down → BUS AC LO L = 1 → BUS DC LO L = 1
1 = low (+0.4 V)

Whenever DC LO L or AC LO L go low, there is sufficient storage in capacitors C1 and C2 to maintain output voltage long enough to permit the power fail circuit to operate. The open collector stages are designed to clamp the Unibus to 0.4 V maximum, even when there is no ac input to the regulator. They are inherently biased on by R11 and R12 until the differential amplifiers signal that power is OK.

3.6.4 PWR OK L Circuit

The circuit shown in Figure 3-8 monitors the AC LO L output. When using the PWR OK L output, AC LO L must be jumpered to the base of Q12. In normal operation, AC LO L is floating and the +15 V and +5 V regulated outputs are present, hence Q12 is conducting. When Q12 is conducting, the PWR OK L output is negated (high). If AC LO L is asserted (low), Q12 turns off and PWR OK L is asserted (low). Note that AC LO L asserted places a ground on the output of the AC LO L circuit, while PWR OK L asserted places a 100 Ω resistor tied to ground on the output of the PWR OK L circuit.

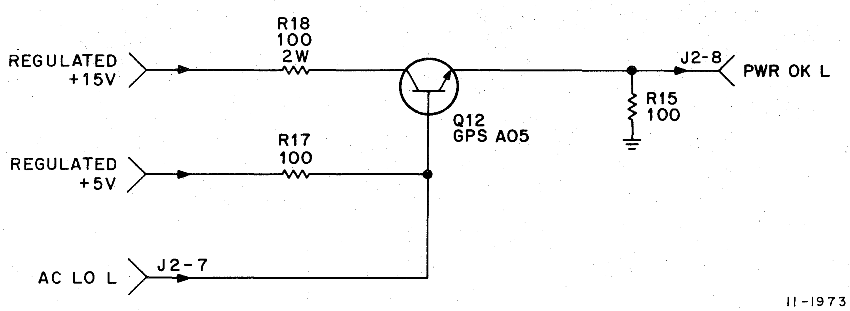


Figure 3-8 PWR OK L Circuit

3.6.5 +15 V Regulator Circuit

The +15 V regulator shown in Figure 3-9 is a simple series regulator. The pass transistor Q1 is a high-gain power Darlington and is mounted on the heat sink. Base drive current is supplied to Q1 via R38. Q3 acts to limit the value of this current to the required value by shunting it away from the Q1 base. Q4, the voltage detector amplifier, biases on Q3 and thus limits current to Q1. The +15 V output voltage is sampled on the viewing chain R34, 35, 36 and compared to the voltage across reference Zener D8, which is fed by R37. If the output should try to increase from the regulated value, the emitter of Q4 is made relatively more negative than its base and conduction through Q4 increases. This increases the conduction through Q3 and causes Q1 to shut down sufficiently to restore the output voltage to the regulated value. Ambient temperature compensation of the voltage detector is essentially flat since D8 has a +2 mV/° C temperature coefficient and the base emitter junction of Q4 has a −2 mV/° C temperature coefficient.

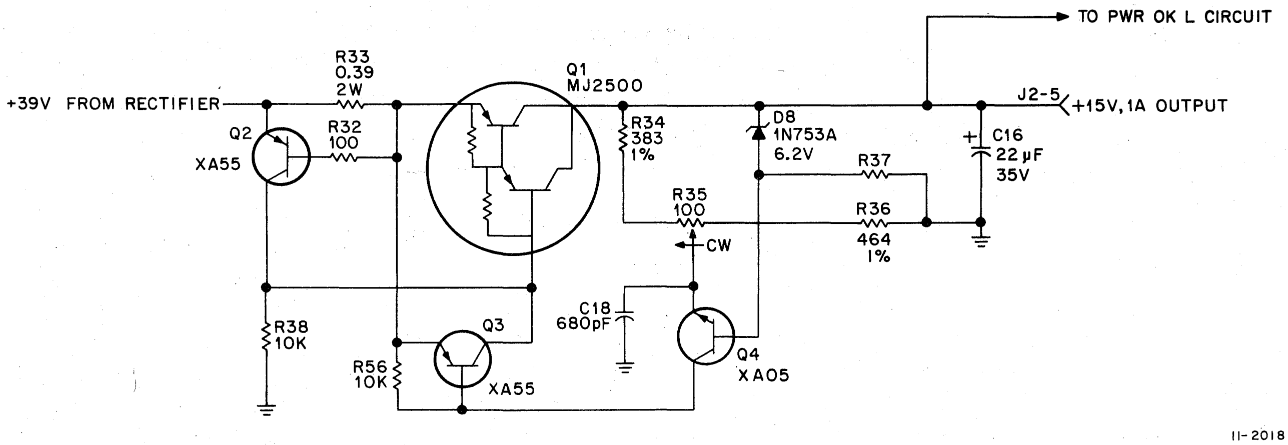


Figure 3-9 +15 V Regulator Circuit

R35 acts as the +15 V voltage adjustment potentiometer. C18 is a high frequency stabilization capacitor. Q2 is the overload detector; when the output current reaches 1.5 A nominal, the voltage across R33 is sufficient to cause Q2 to conduct. This removes base drive from Q1 and causes the regulator to current limit.

3.6.6 +5 V Regulator Circuit

The +5 V regulator is similar to the +15 V regulator in that the sampled output voltage is compared to the voltage across a reference Zener by a voltage detector transistor, which in turn controls the drivers for the main pass transistor. The +5 V regulator circuit is shown in Figure 3-10. An over current circuit is likewise employed.

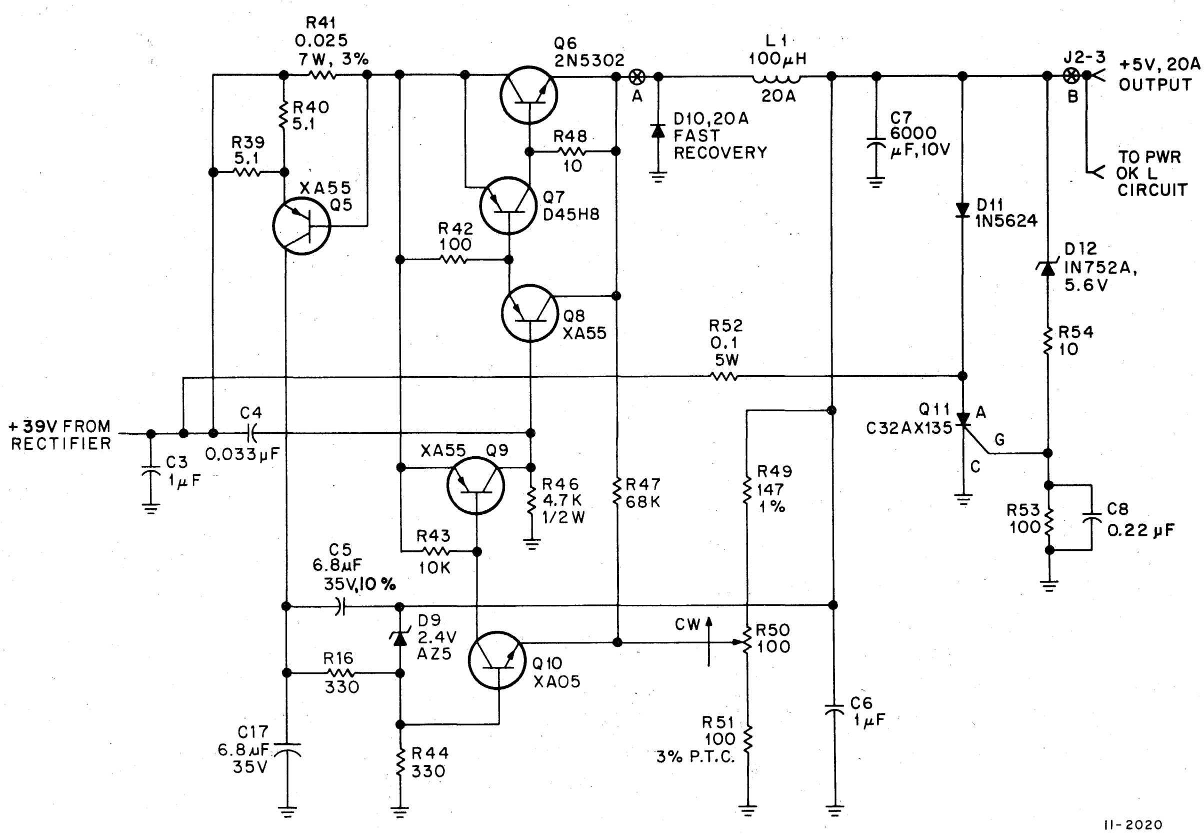


Figure 3-10 +5 V Regulator Circuit

The viewing chain consists of R49, 50, 51 and the reference Zener, D9, which is fed by R44. Q10 is the detector amplifier. The pass transistor Q6 and first stage driver Q7 are mounted on the heat sink. The predriver Q8 is turned on by R46. The current is diverted from the base of Q8 by off-driver Q9, which is controlled by Q10. The +15 V and +5 V regulators are similar in operation, i.e., a tendency for the output voltage to rise results in more conduction through Q10 and resultant limiting of conduction through Q6.

Here the similarity ends. The +5 V circuit is a regulator that operates in the switching mode for increased efficiency. To get the regulator to switch, positive feedback is applied to the voltage detector input via R47. Thus the whole regulator acts as a power Schmitt trigger and is either completely turned on or turned off, depending on whether the output voltage is too high or too low. When Q6 is on, it supplies current through filter choke L1 to the output smoothing capacitor C7 and the load. When Q6 is off, the L1 current decays through commutating diode D10, which becomes forward biased by the back EMF of L1. The waveform across D10 is a 30 V nominal rectangular pulse train. The filtered output across C7 is thus +5 V with about a 200-mV peak-to-peak, 10-kHz nominal sawtooth of super-imposed ripple. At the crest of the ripple, Q6 turns off, at the valley, Q6 turns on. This switching mode of operation limits the dissipation in the circuit to the saturated forward losses of Q6 and D10 and the switching losses of Q6. The resultant high efficiency allows the heat sink to be small and reduces the number of power semiconductors required.

R50 is the voltage adjustment potentiometer. R51 is a positive temperature coefficient wire-wound resistor that compensates for the fact that the Q10 base-emitter junction and the reference diode D9 both have negative voltage temperature coefficients. Q5, current limited by R39, 40, detects the overcurrent signal generated across resistor R41, which is in series with the Q6 collector.

Output fault current is limited to a safe value because conduction of Q5 makes the reference voltage across D9 decrease to zero. This causes Q10 to conduct and shuts down the regulator. C5 is an averaging capacitor, which is necessary in the circuit because the current through R41 is pulsating.

High frequency bypass capacitors, C3 and C6, are used on input and output of the regulator, respectively. C4 is used to slow down the turn-on of Q6 to allow D10 to recover from the on state without a large reverse current spike.

In the event that a malfunction causes the output voltage to increase beyond about 6.8 V nominal, Zener diode D12 will conduct and fire silicon-controlled rectifier Q11. This will crowbar the output voltage to a low value through D11 and will blow fuse F1 in the rectifier circuit through R52.

3.6.7 −15 V Regulator Circuit

The −15 V regulator circuit is shown in Figure 3-11. It is essentially the complement of the +5 V regulator circuit and differs only in minor detail.

The crowbar device is a Triac Q27 instead of an SCR; no temperature compensating resistor is required because Q26 and D4 track each other, as in the +15 V regulator; the detailed interconnection of the drivers and the circuit values are different. The −15 V output voltage is adjusted by potentiometer R26.

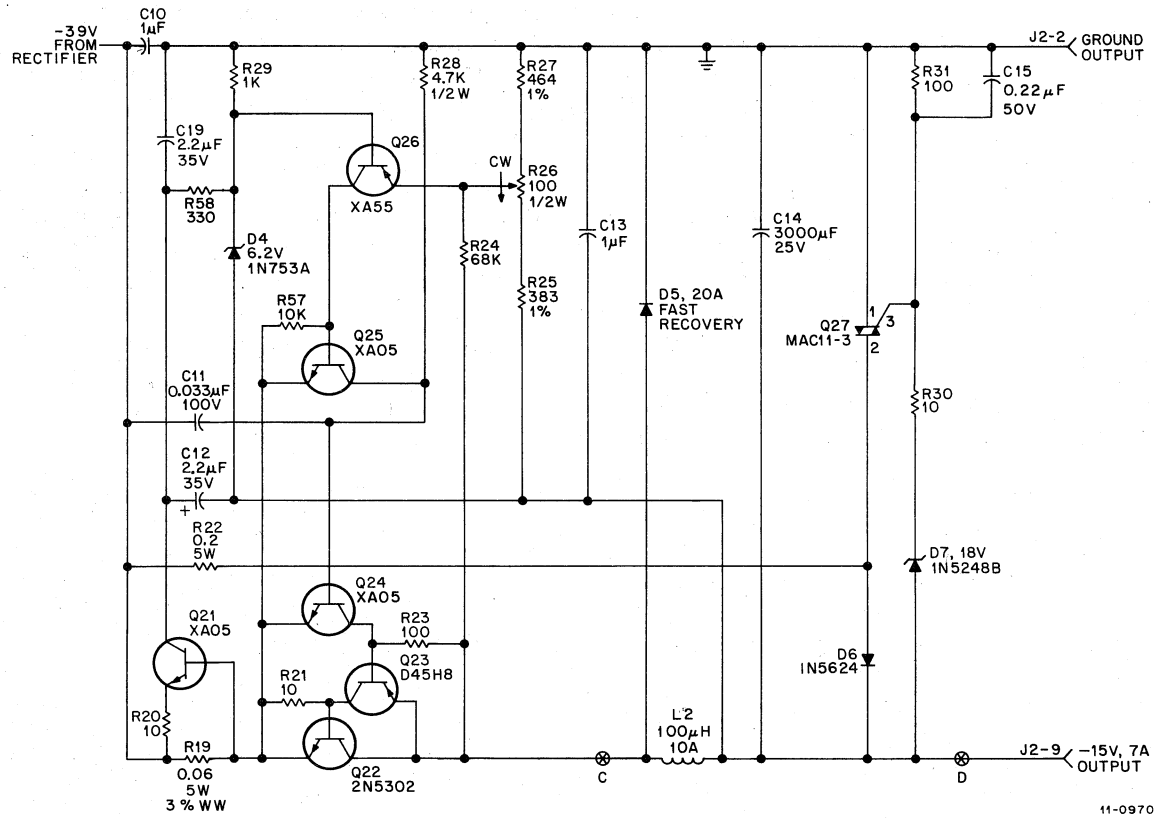


Figure 3-11 -15 V Regulator Circuit

CHAPTER 4
MAINTENANCE

4.1 INTRODUCTION

This chapter contains power supply maintenance information consisting of adjustments, circuit waveforms, and troubleshooting. The adjustments consist of three output potentiometers. The circuit waveforms provide a guide to proper operation at various places in the circuit. The troubleshooting section provides rules, hints, and a troubleshooting chart as a maintenance aid in isolating power supply malfunctions.

4.2 ADJUSTMENTS

There are only three adjustments to the power supply. These adjust the three dc output voltages: +15 V, +5 V, and −15 V. A small screwdriver is all that is required. Clockwise adjustment of any of the potentiometers increases voltage, and the potentiometers are located on the top side of the dc regulator module. The potentiometer designations are:

a. R35 (+15 V)
b. R50 (+5 V)
c. R26 (−15 V)

In performing any of these adjustments note the following:

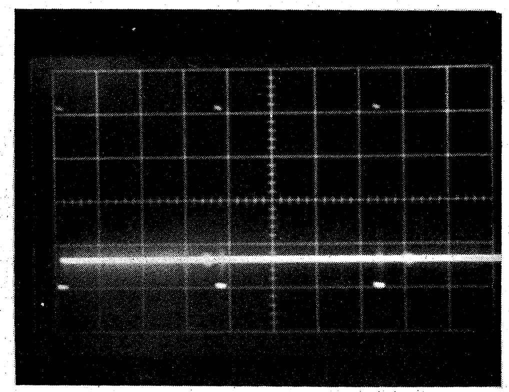
CAUTION

1. **Do not adjust voltages beyond their 105 percent rating and adjust slowly to avoid overvoltage crowbar, which will blow dc output fuses.**

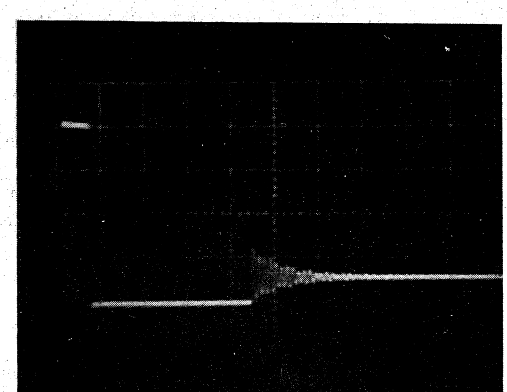
2. **Use a calibrated voltmeter, preferably a digital voltmeter. Voltages should be adjusted to their center values: +15.0, +5.0, and −15.0, all under load at the dc output connector.**

4.3 CIRCUIT WAVEFORMS

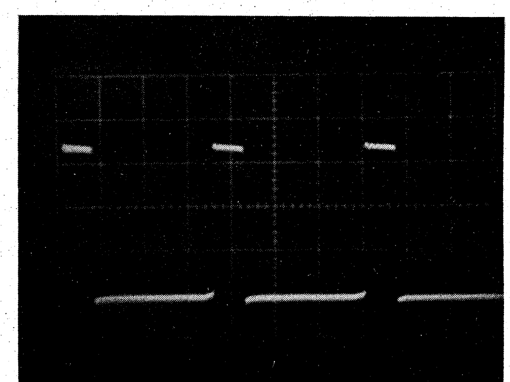
The two switching regulator circuits used on the dc regulator module generate +5 V and −15 V. Figure 4-1 shows six waveforms of the +5 V regulator circuit taken at two points (A and B) in the circuit (Figure 3-10). Waveforms a, b, and c are taken at point A, which is the +5 V circuit, Q6 transistor output. Waveforms d, e, and f are taken at point B, which is +5 V power supply output. Figure 4-1 also indicates the load conditions and time scales for each waveform. Figure 4-2 shows six waveforms of the −15 V regulator circuit taken at two points (C and D) in the circuit (Figure 3-11). Waveforms a, b, and c are taken at point C, which is the −15 V circuit, Q22 transistor output. Waveforms d, e, and f are taken at point D, which is the −15 V power supply output. The load conditions and time scales of the respective waveforms are indicated in Figure 4-2. These waveforms were taken on a Tektronix Model 453 oscilloscope. To locate the circuit test points on the dc regulator module, refer to engineering drawing E-IA-5409728-0-0. All waveforms are with respect to power supply common.



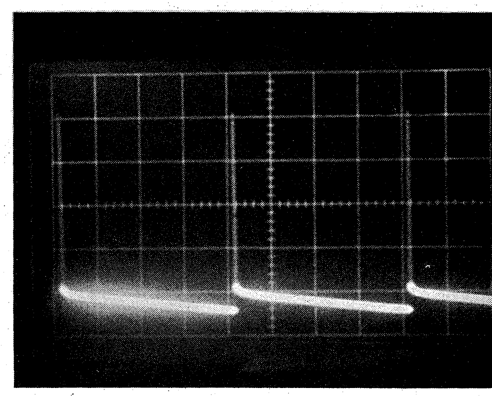
a) Point A, No load,
2 ms /div, and
10V/div.



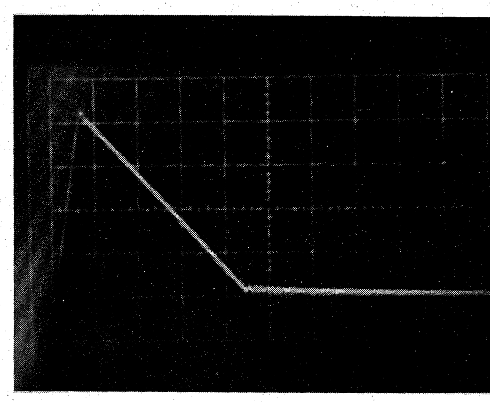
b) Point A, No load,
20 μs/div, and
10V/div.



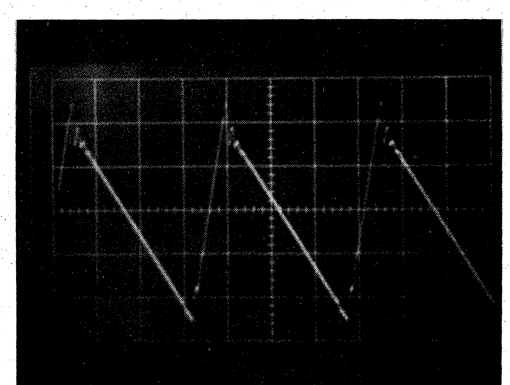
c) Point A, 20A load,
20 μs/div, and
10V/div.



d) Point B, No load,
2 ms/div, and
50 mV/div.

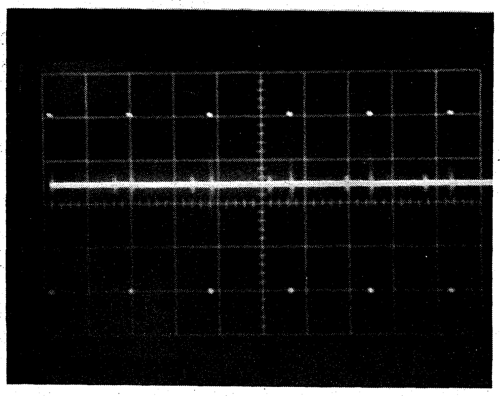


e) Point B, No load,
20 μs/div, and
50 mV/div.

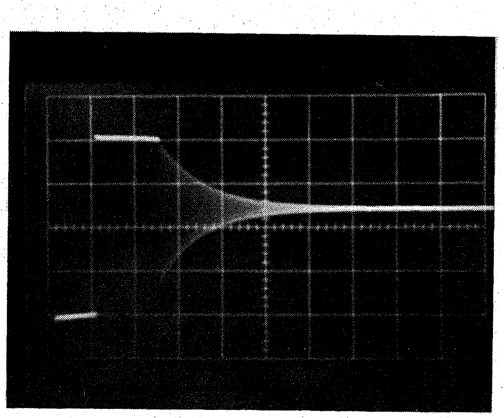


f) Point B, 20A load,
μs/div, and
50 mV/div.

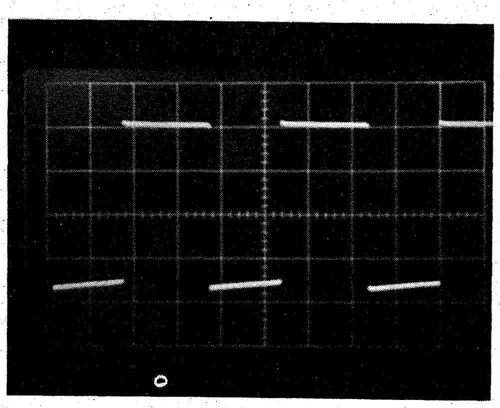
Figure 4-1 +5 V Regulator Circuit Waveforms



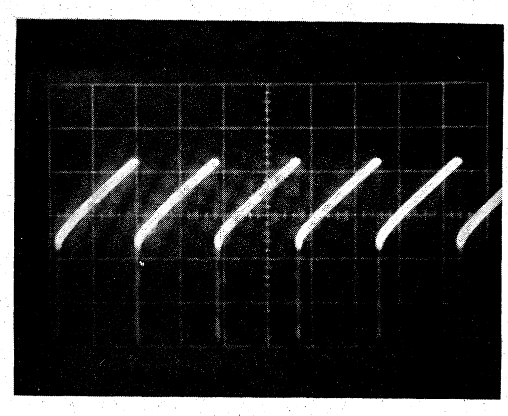
a) Point C, No load,
5 ms/div, and
10V/div.



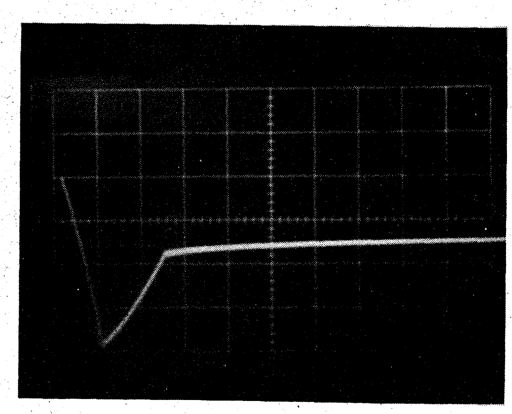
b) Point C, No load,
50 μs/div, and
10V/div.



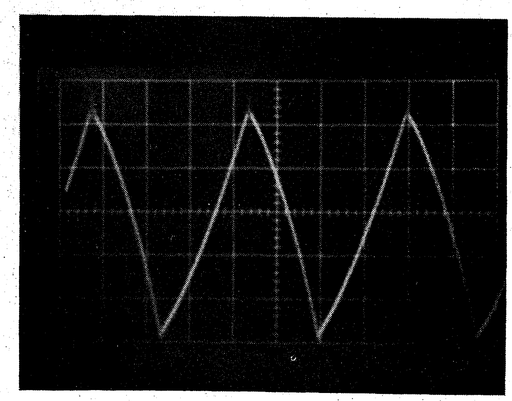
c) Point C, 5A load,
50 μs/div, and
10V/div.



d) Point D, No load,
5 ms/div, and
50 mV/div.



e) Point D, No load,
50 μs/div, and
50 mV/div.



f) Point D, 5A load,
50 μs/div, and
50 mV/div.

Figure 4-2 −15 V Regulator Circuit Waveforms

4.4 TROUBLESHOOTING

Troubleshooting information for the power supply consists of troubleshooting rules, hints, and a troubleshooting chart. This information provides a maintenance aid to isolating power supply malfunctions (engineering drawing D-CS-5409728-0-1).

4.4.1 Troubleshooting Rules

Troubleshooting rules for the power supply are listed as follows:

a. Ensure that power cord is unplugged before servicing the power supply.

b. Ensure that input capacitors C1 and C2 are discharged before servicing the power supply. A 10 to 100 Ω, 10 W resistor can be used to hasten the discharge of the capacitors. (Be sure power is off.)

c. The dc regulator module is not internally grounded to the chassis; therefore, shorts to ground can be located.

d. The dc output fuses F1 and F2 can be replaced without removing the dc regulator module. Before unsoldering fuses, observe cautions described in steps a and b.

e. For proper operation, all hardware must be secured tightly to about 12 in./lb (i.e., capacitors, chokes, semiconductors). All hardware should be replaced with identical hardware replacement parts.

f. The dc regulator module may be removed from the top of the power chassis assembly while the latter is still bolted to the cabinet. The dc regulator module is held in place by six screws.

g. When replacing power semiconductor components that are secured to the heat sink, apply a thin coat of Wakefield no. 128 compound or Dow silicone grease to the heat sink contact side (bottom) of the semiconductor. Insulating wafers are not required.

4.4.2 Troubleshooting Hints

CAUTION
Disconnect all power supply outputs.

The most likely source of power supply malfunction is the dc regulator module. A quick remedy for a malfunction may be to replace the entire module. The problem, however, could be a short in the device connected to the power supply or possibly a defective component in the power supply ac input circuit.

The +5 V and −15 V regulators contain overvoltage detection circuitry. If R50 or R26 is adjusted too far clockwise, the corresponding crowbar circuit will trip and blow fuses. To correct this condition: adjust the potentiometer fully counterclockwise, replace the blown fuse, and re-adjust per Paragraph 4.2.

Make a visual examination of the circuitry. Check for burnt resistors, cracked transistors, burnt printed circuit board etch, oil leaking from capacitors, and loose connections. A visual check can be a quick method of locating the cause of a malfunction.

4.4.3 Troubleshooting Chart

In checking the various areas of the power supply, the rules listed in Paragraph 4.4.1 should be followed. The waveforms shown in Paragraph 4.3 provide a comparison for the troubleshooting readings. Table 4-1 provides the dc regulator troubleshooting chart.

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Table 4-1
Troubleshooting Chart

Problem	Cause
No +5 V and +15 V output	F1 opened D14 or transformer opened +5 V adjusted too high*
+5 V output too low	Q5, D9, Q10, Q9, Q11, D12, or D10 shorted C5 or C7 shorted R49, R50, R46, or R44 opened Q6, Q7, Q8, or D11 shorted A9, Q10, or D9 opened* R51, or R50 opened
+15 V output too high	Q1 shorted E8 opened R35 or R36 opened
No -15 V output	F2 opened D14 or transformer opened -15 V adjusted too high*
-15 V output too low	Q25, D4, Q26, Q21, Q27, D7 or D5 shorted C14 or C12 shorted R22, R26, R25, R29 opened Q22, Q23, Q24, or D6 shorted Q25, Q26, or D4 opened R26 or R27 opened* -15 V adjusted too high*
AC LO L will not go high	Q13, Q14, or Q15 shorted Q16 or D3 opened R7, R3, R6, or R8 opened C9 shorted
AC LO L will not go low and/or acts erratically on Power-On/Power-Off	Q13, Q14, or Q16 opened Q15 or D3 shorted R12, R13, R7, or R10 opened
DC LO L will not go high	Q19, Q20, or Q12 shorted Q17 or D3 opened R7, R2, or R6 opened C9 shorted

* This set of causes makes the crowbar fire, which in turn blows the appropriate fuse.

Table 4-1 (Cont)
Troubleshooting Chart

Problem	Cause
DC LO L will not go low	Q19, Q20, or Q17 opened Q17 or D3 opened R7, R3, or R6 opened C9 shorted
DC LO L will not go low and/or acts erratically on Power-On/Power-Off	Q19, Q20, or Q17 opened Q18 or D3 shorted R9, R10, R11, or R8 opened
No LTC L signal	R55 opened D13 shorted
LTC L going too high	D13 opened
PWR OK L will not go high	Q12, R18, or R17 opened
PWR OK L will not go low	R15 opened or Q12 shorted

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