PART 4

POWER SUPPLY

Part 4 provides specifications and a general physical description of the power supply. A detailed circuit description and maintenance information are also included. The chapters of Part 4 are:

CHAPTER 14
POWER SUPPLY GENERAL DESCRIPTION

14.1 INTRODUCTION

The power supply is a forced air-cooled unit that converts single-phase 115V or 230V nominal, 47-63 Hz line voltage to the three regulated output voltages required by the computer. The output voltages and their principal uses and characteristics are:

Voltage	Use	Characteristics
+15V	Communication Circuits	Series regulated and overcurrent protected.
+5V	IC Logic	Switching regulated and overvoltage and overcurrent protected.
-15V	Core Memory	Switching regulated and overvoltage and overcurrent protected.

The power supply is used in conjunction with the BC05HXX (115V) or BC05JXX (230V) Power Control Assemblies, which contain a line cord, circuit breaker, and RF1 capacitors. Line cord length is specified in the part number; e.g., 115V, 6 feet is designated BC05H06.

The power circuitry also generates BUS AC LO L and DC LO L power fail early warning signals, and the LTC L real-time clock synchronizing signal.

A thermal control mounted on the heat sink will interrupt the ac input should the heat sink temperature become excessive due to fan failure or other cause.

14.2 PHYSICAL DESCRIPTION

The power supply comprises three major subassemblies and two cables: the power control unit, power chassis assembly, dc regulator module, dc cable, and ac cable.

14.2.1 Power Control Unit

The power control unit (drawing H400-0-0) is mounted to the rear of the computer by two screws. It contains line cord, circuit breaker, RFI capacitors, 115V or 230V connections for the power supply transformer, and an output 6-socket Mate-N-Lok connector. Physically, it consists of a sheet metal bracket and a slide-on cover that is locked in place by one screw. A single pole thermal breaker and a line cord strain-relief grommet are mounted on the flange of the bracket, making the line cord and breaker reset button accessible on the rear of the computer.

A small printed circuit card is mounted directly to the breaker terminals. This card interconnects and mounts the RFI dual-disc ceramic capacitor, the output Mate-N-Lok connector and three fast-tabs for ac input and ground connections. A dual fast-tab is connected directly to the bracket. The black and white line cord wires are connected via fast-tab to the PC card; the green (ground) line cord wire is connected to the dual fast-tab, which in turn is connected to the third fast-tab on the PC card.

The 115V and 230V models differ in only two respects: breaker current rating and (printed circuit) jumpers for parallel or series connection of the power supply transformer primaries. Power control part numbers are: BC05HXX - 115V, 7A; and BC05JXX - 230V, 4A; where XX denotes line cord length; e.g., BC05H06 has a 6 foot line cord.

14.2.2 Power Chassis Assembly

The 700 8731 Power Chassis Assembly (Figures 14-1 and 14-2) consists of a long, inverted U-shaped chassis, 700-8726 power transformer, and a 5-inch fan. It is secured to the bottom of the computer by four 8-32 by 3/8 inch Phillips pan-head bolts.

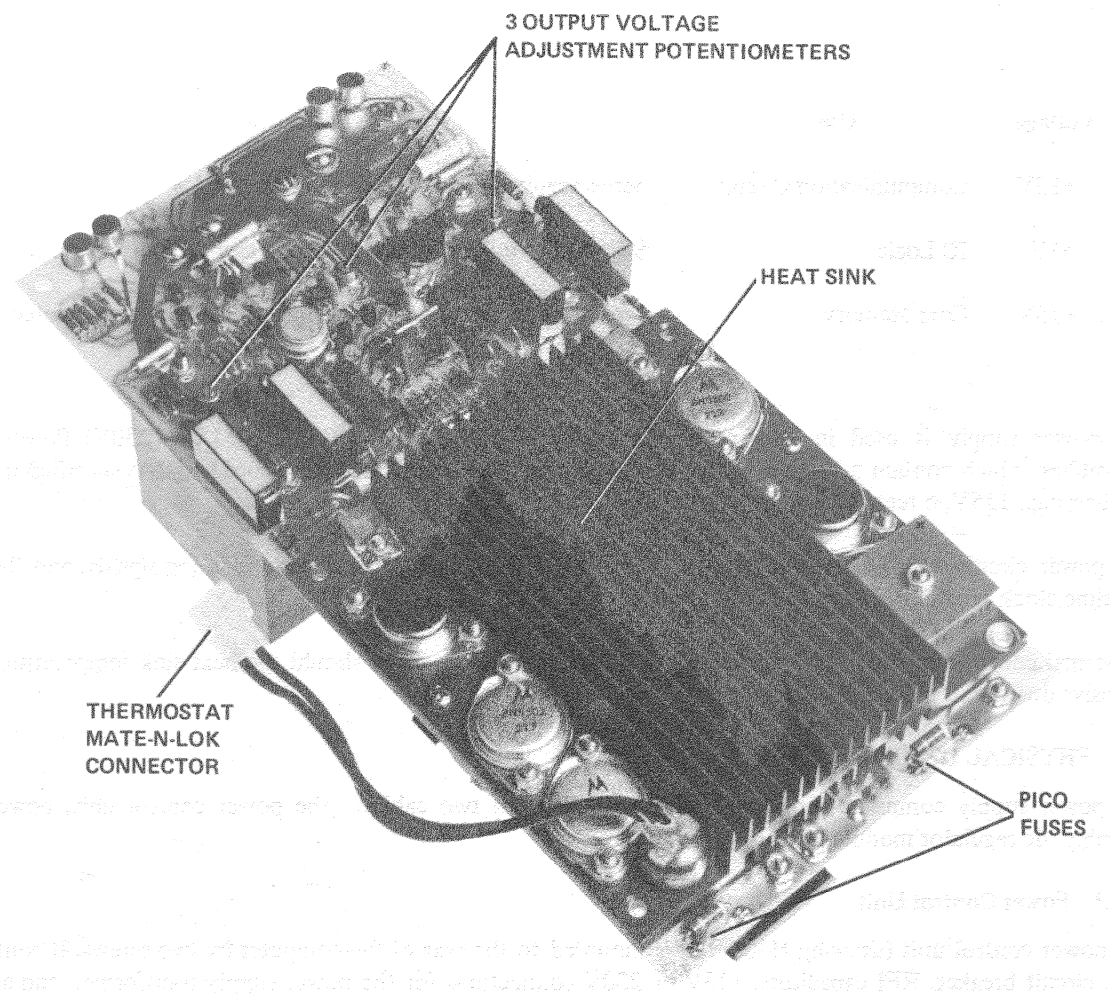


Figure 14-1 Power Chassis Assembly (with DC Regulator Module)

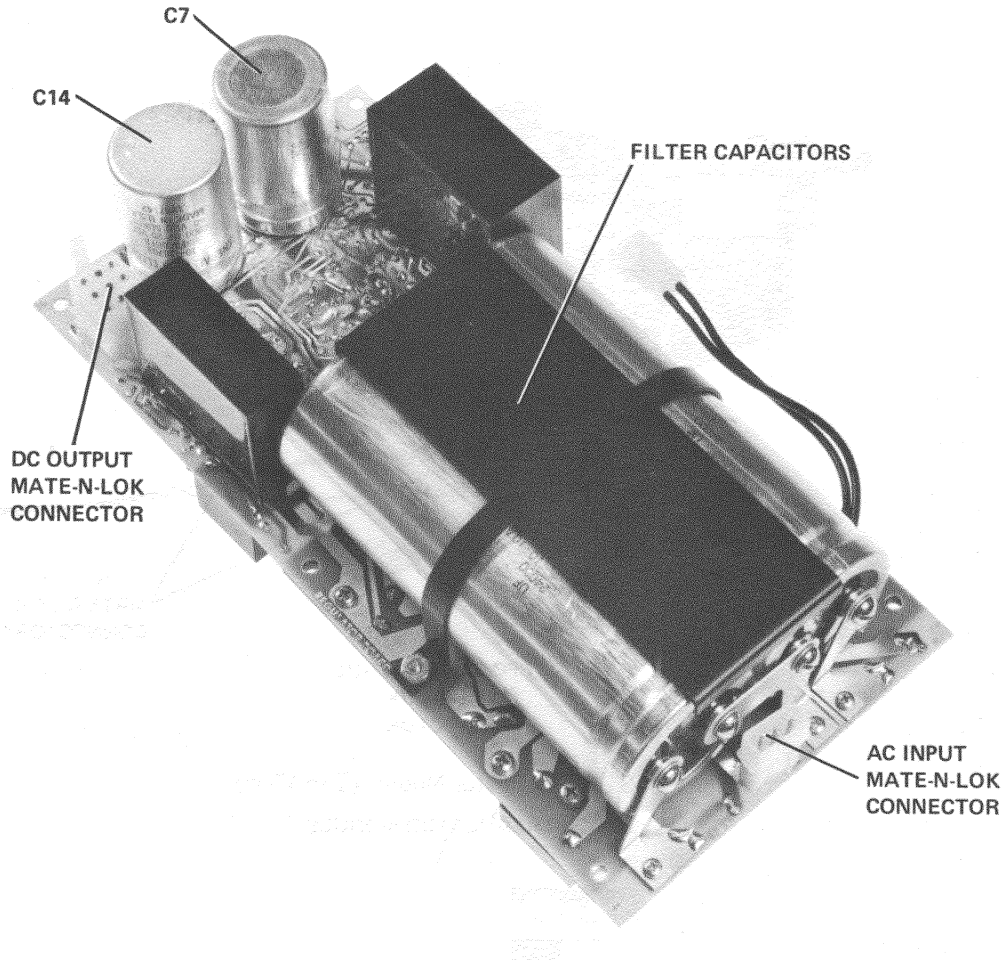


Figure 14-2 Power Supply Assembly (with DC Regulator Module Removed)

The chassis is mounted to the right of the connector blocks, when viewed from the front, and airflow is from front to rear. The fan is held to one end of the chassis by two screws; the transformer is held to the other end by four mounting studs. The transformer may be removed by loosening four nuts, which are accessible through large holes on the bottom of the power chassis.

The dc regulator module is mounted to the chassis assembly by six screws and must be removed for cable access. The dc cable enters a slot on the connector block side of the chassis; the ac cable enters a slot on the other side.

Connections to the fan are made by small fast-tabs; connections to the transformer are made via Mate-N-Lok connectors: 6-pin for primary, 3-socket for secondary.

14.2.3 DC Regulator Module

The 5409728 DC Regulator Module (Figures 14-3 and 14-4) is a printed circuit assembly, mounted to the power chassis assembly by four 6-32 by 9/16 inch and two 6-32 by 1/4 inch Phillips pan-head screws.

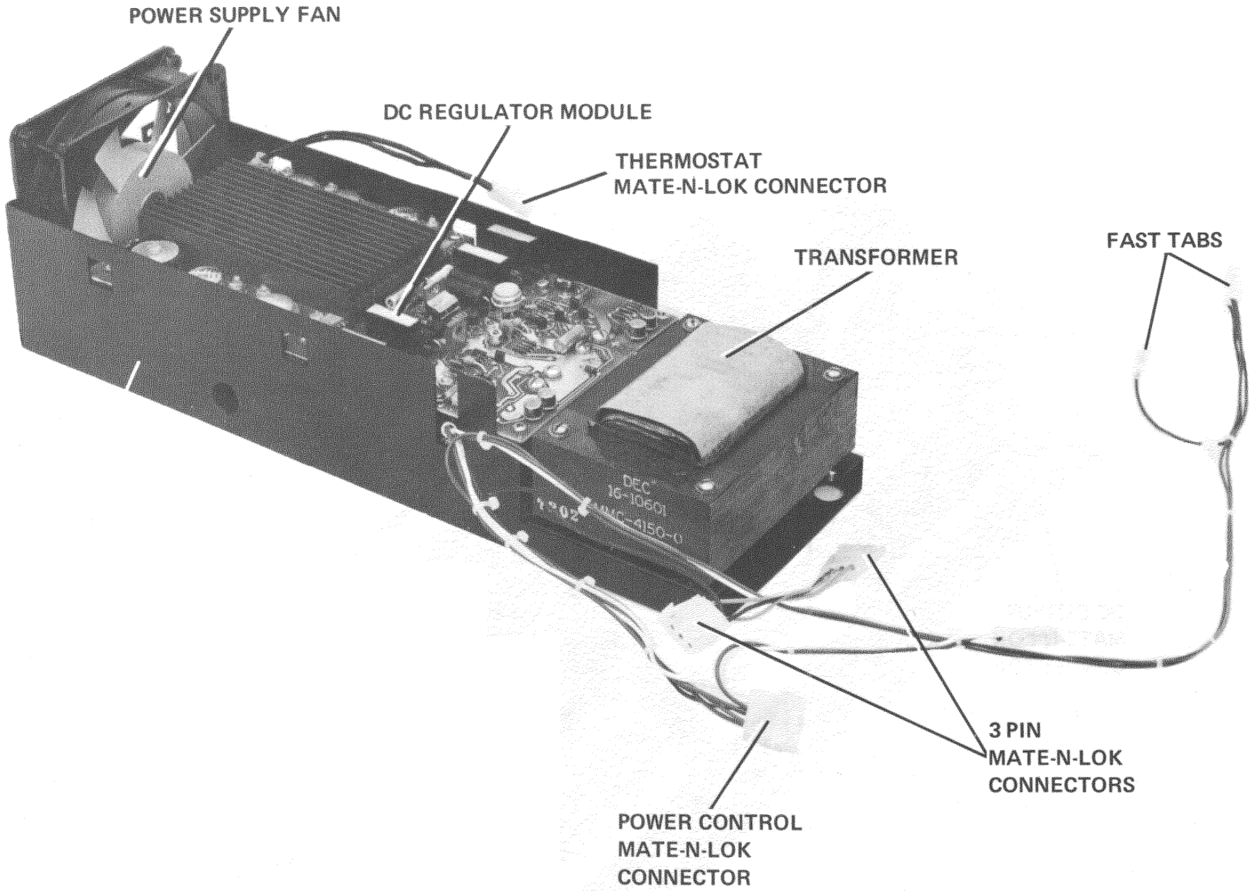


Figure 14-3 DC Regulator Module (Top View)

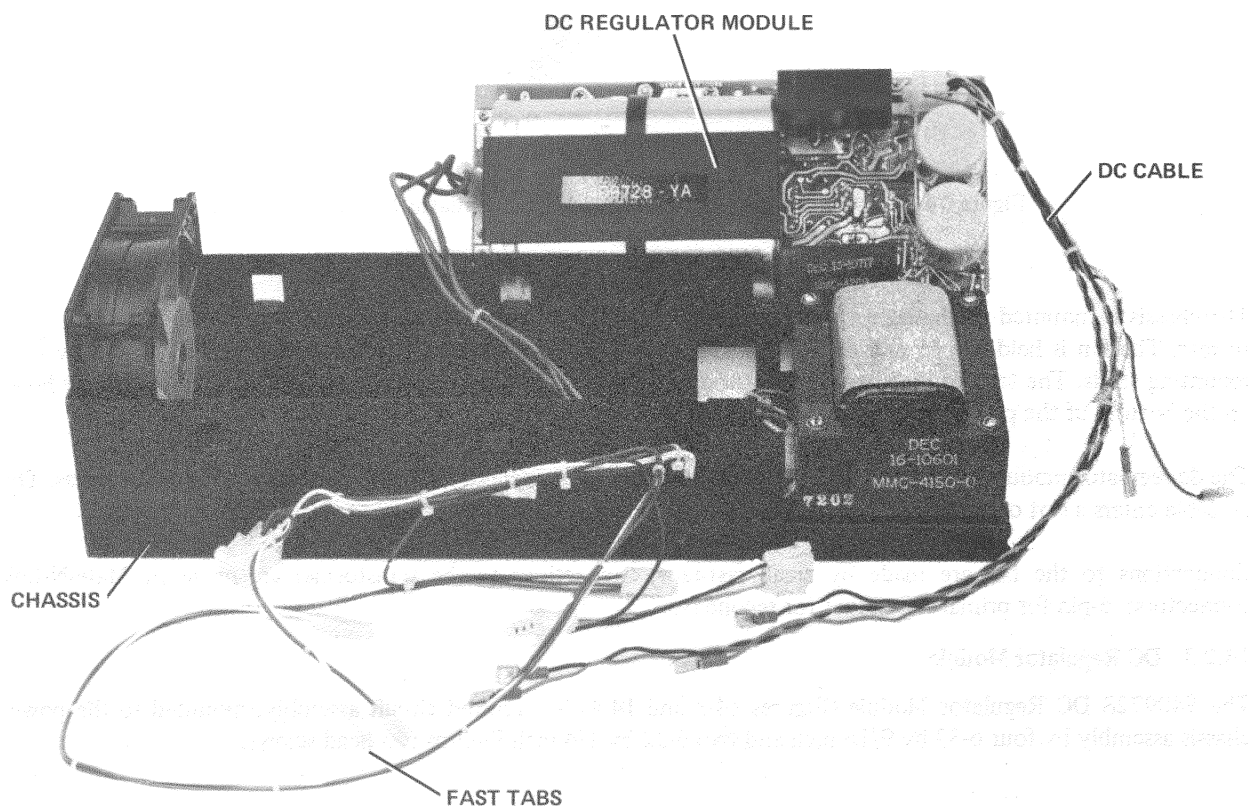


Figure 14-4 DC Regulator Module (Bottom View In Mounting Box)

Computers that were shipped during the first three or four months of production use a dc regulator module designated 5409728-YA-0; later shipments use a module designated 5409728-0-0, E revision. There are differences in component values on the two modules. The discussion of the dc regulator module circuits in this manual is directed to the later module, designated 5409728-0-0. Engineering drawings applicable to the module used are shipped with the equipment. These drawings provide schematics and component values of the dc regulator module.

This module contains all the circuitry between the transformer secondary winding and the power supply output cable. The transformer secondary 3-socket Mate-N-Lok connector is plugged into a mating connector that is soldered directly to the printed circuit board and is accessible underneath it. The 9-pin Mate-N-Lok connector on the dc output cable to the computer is similarly mated to a connector underneath the other end of the board.

The dc regulator module may be probed for troubleshooting purposes from the top; all points on the circuit are available. It may also be removed from the top for cable access and for parts replacement by removing the six mounting screws.

The printed circuit is approximately 5 by 10 inches, with about half of the top surface devoted to the heat sink. The power transistors and power rectifiers are bolted to two shelves on the sides of the heat sink and make contact with the circuit board directly underneath via solder and screw connections. The heat sink is hard anodized for electrical insulation.

The other half of the top surface is devoted to interconnecting and mounting the balance of the circuit. Three small output voltage adjustment potentiometers are accessible on this top portion of the board.

Two small pico fuses are mounted on the top of the PC board on the fan end. These fast-acting fuses will typically only blow when some component is defective or when the +5V or -15V is too high. The two input filter capacitors are held to the underside of the board by a bracket and are connected to the circuit via jumper tabs on the fan end.

The +5V and -15V output filter capacitors and inductors are also mounted under the board, the former by screws and the latter by nuts.

Care must be taken to ensure that all electrical and mechanical connections are secure. In manufacturing, the hardware is tightened with a torquing device set to 12 inch-pounds.

14.2.4 DC Cable

This is a simple cable connecting the computer module to the dc power module via a 9-pin Mate-N-Lok. The latter is made accessible by loosening the six mounting screws and lifting out the dc module. Cable access is through a slot on the computer module side of the power chassis.

14.2.5 AC Cable

This cable interconnects all ac portions of the computer chassis (Figures 14-1 through 14-4). The ac portions of the computer chassis are as follows:

a. Power Supply Fan – two fast-tabs
b. Power Supply Thermostat – one 2-pin Mate-N-Lok
c. Memory Section Fan – two fast-tabs
d. Transformer Primary – one 6-socket Mate-N-Lok
e. Power Control – one 6-pin Mate-N-Lok
f. PDP-11 System AC Power Control – two 3-pin Mate-N-Lok connectors on rear of computer.

The ac cable is located on the right-hand side and rear of the computer and is inherently shielded by the power supply chassis and the computer chassis.

14.3 Specifications

Tables 14-1, 14-2, and 14-3 list all the power supply specifications according to input, output, and mechanical and environmental specifications.

Table 14-1
Power Supply Input Specifications

Parameters	Specifications
*Input Voltage (1 phase, 2 wires and ground)	95–135/190–270V
Input Frequency	47–63 Hz
Input Current	5/2.5A RMS
Input Power	325W at full load
Inrush	80/40A peak, 1 cycle
Rise Time of Output Voltages	30 ms max. at full load, low line
Input Overvoltage Transient	180/360V, 1 sec 360/720V, 1 ms
Storage After Line Failure	25 ms min., starting at low line, full load
Input Breaker (part of BC05 Power Control)	7A/4A single-pole, manually reset, thermal
Thermostat Mounted on Heat Sink (opens transformer and fan power)	277V 7.2A contacts Opens 98–105°C Automatically resets 56–69°C
Input Connections	Line cord on BC05 Power Control, length and plug type specified with BC05 (Paragraph 2.2.1.1)
Turn-On/Turn-Off	Application or removal of power
Hipot (input to chassis and output)	2.1 kV/dc, 60 sec

*Input voltage selection, 115V or 230V, is made by specifying the appropriate AC Input Box, DEC Model BC05. All specifications are with respect to the BC05 input.

Table 14-2
Power Supply Output Specifications

Parameter	Specification
+15V	
Load Range	
Static	0–1A
Dynamic	0–1A
Max. Bypass Capacitance in load for 30 ms turn-on	500 mF
Overvoltage protection	None
Current limit at 25°C	1.3A to 1.7A (-6.2 mA/°C)
Backup Fuse	15A (also used for +5V)
Adjustment	±5% min.
Regulation (All causes including line, load, ripple, noise, drift, ambient temperature)	±5%
+5V	
Load Range	
Static	0–15A
Dynamic #1	±5A (within 0–17A load range)
Dynamic #2	No load – full load
Max. Bypass Capacitance in load for 30-ms turn-on	2000 μF
Overvoltage Crowbar (blows fuse)	5.7–6.8V actuate (7V abs. max. output)
Current Limit at 25°C	24–29.4A (-0.1A/°C)
Backup Fuse (series with raw dc)	15A
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 (0–60°)	±1%

Table 14-2 (Cont)
Power Supply Output Specifications

Parameter	Specification
-15V	
Load Range	
Static	0–7A
Dynamic #1	$\Delta I = 5A\ (0.5A/\mu s)$
Dynamic #2	No load – full load ($0.5A/\mu s$)
Max. Bypass Capacitance in load for 30-ms turn-on	1000 μF
Overvoltage Crowbar (blows fuse)	17.4–20.5V (22V abs. max. output)
Current Limit at 25°C	10–13.3A (-0.03A/°C)
Backup Fuse (series with raw dc)	5A
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 (0–60°C)	±1%
BUS DC LO L and BUS AC LO L	
Static Performance at Full Load (for 230V connection, double below voltages)	
BUS DC LO L goes to high	74–80 Vac line voltage
BUS AC LO L goes to high	8–11V higher
BUS AC LO L drops to low	80–86 Vac line voltage
BUS DC LO L drops to low	7–10V lower
Hysteresis (contained in above specifications)	3–4 Vac
Output voltages still good	70 Vac line voltage

Table 14-2 (Cont)
Power Supply Output Specifications

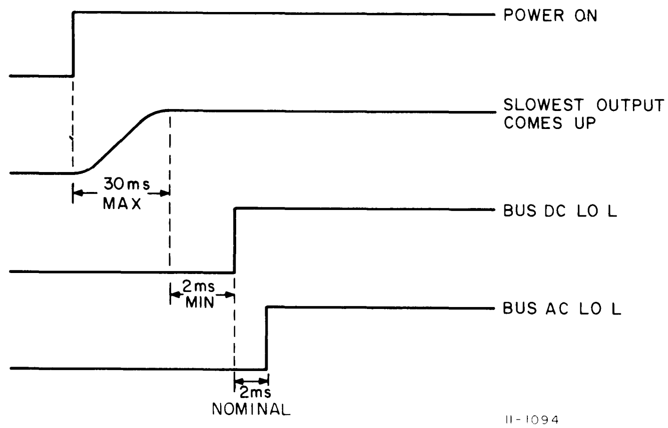
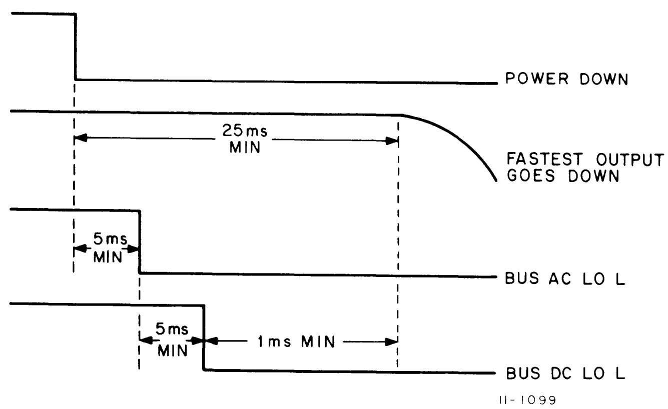
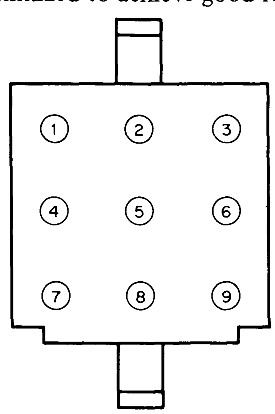
Parameter	Specification
BUS DC LO L and BUS AC LO L (Cont)	
Dynamic Performance	
Worst case on power-up is high line, full load.	
Worst case on power-down is low line, full load.	
Output Characteristics	
Open Collector	50 mA sinking capability +0.4V max. offset
Pull-Up Voltage on Unibus	5V nominal, 180Ω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

Table 14-3
Mechanical and Environmental Specifications

Parameter	Specification
Weight	
DC Regulator	7 lb approx.
Power Chassis Assembly including AC Regulator Module	18 lb approx.
Dimensions	16.50 in. length 5.19 in. width 3.25 in. height
Cooling Means	Integral 5 in. fan
Minimum Cooling Requirements	375 CFM through heat sink 250 CFM over caps, chokes, and transformer
Rated Heat Sink Temperature	95°C max.
Shock, Non-Operating	40G (duration 30 ms) 1/2 sine in each of six orientations
Vibration, Non-Operating	1.89G RMS average, 8G 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	10K ft

Output parameters are specified at the pins of the 9-pin Mate-N-Lok connector (Figure 14-5) which plugs into the output connector on the 5409728 module. All output voltages are given with respect to the common ground pin on this connector. IR drops in the distribution wiring are minimized to achieve good regulation at the load.

Pin 1 BUS AC LO L
Pin 2 Common
Pin 3 +5V output
Pin 4 LTCL (Clock Signal)
Pin 5 +15V output
Pin 6 BUS DC LO L
Pin 7 Not used
Pin 8 Not used
Pin 9 -15V output



NOTES:

1. The circuit connected to pins 7 and 8 is not used in the PDP-11.
2. Pin 2 is not connected to chassis within the power supply. Chassis ground is made at the backplane.

Figure 14-5 Output Connector, 5409728 Regulator Module

CHAPTER 15
POWER SUPPLY DETAILED DESCRIPTION

15.1 INTRODUCTION

The power supply is divided into two sections: the ac input circuit and the dc regulator module. A detailed description to the circuit level is provided for each section. The ac input circuit description discusses the power supply interconnections, power control, power switch, transformer, power control circuit breaker, and the power supply thermostat. The dc regulator module operation description discusses the generation at the circuit level of each of the five power supply outputs.

15.2 AC INPUT CIRCUIT

A detailed ac interconnection diagram is shown in Figure 15-1. Figures 15-2 and 15-3 give this information in schematic form.

The line cord, single pole breaker, RFI capacitors, and connections for transformer 115V or 230V wiring are contained in the power control unit. To select 115V input or 230V input, use the BC05H or BC05J power control unit, respectively.

A 3-section managed keyswitch is employed and mounted on the console. One section interrupts the power to the transformer primary. A second section is wired to two 3-pin Mate-N-Loks; if the PDP-11 cabinet power control bus is plugged into one of these connectors, the keyswitch will turn on the whole cabinet as well as the computer. The other three-pin Mate-N-Lok is provided for daisy-chaining in the cabinet power control system. The third section of the keyswitch is for Panel Lock and is described in Chapter 4.

The transformer is rated for 47-63 Hz and is equipped with two windings that are connected by the power control in parallel for 115V operation and in series for 230V. The fans are connected across half of the primary so that they are always provided with 115V nominal. There is an electrostatic shield between primary and secondary of the transformer.

The power control circuit breaker contains a single-pole thermal circuit breaker that protects against input overload and is reset by pressing a button on the rear of the computer.

The thermostat is mounted on the power supply heat sink. If the heat sink temperature rises to about 100°C, the thermostat will open one side of the primary circuit and de-energize the power supply. It will automatically reset at about 64°C.

15.3 DC REGULATOR MODULE OPERATION

The discussion of the DC Regulator Module circuits in this manual is directed to the module designated 5409728-0-0, rather than the earlier module designated 5409728-YA-0. A block diagram of this module is shown in Figure 15-4. The center tapped output of the power transformer is applied to positive and negative rectifier and filter circuits. The rectifier circuits produce +28V and -28V nominal raw dc voltages which are unregulated but well filtered by the input storage capacitors.

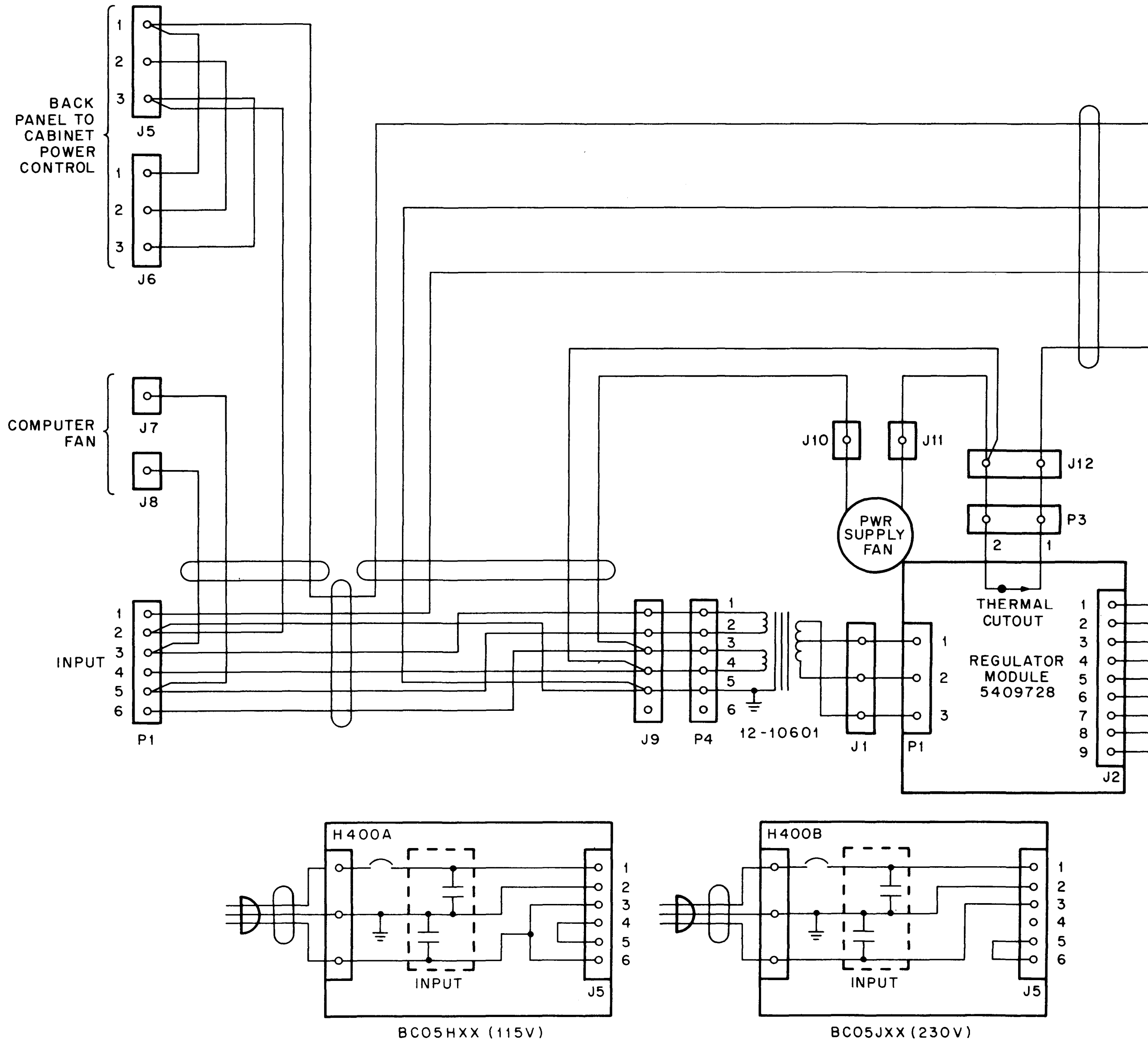


Figure 15-1 Detailed AC Interconnection Diagram

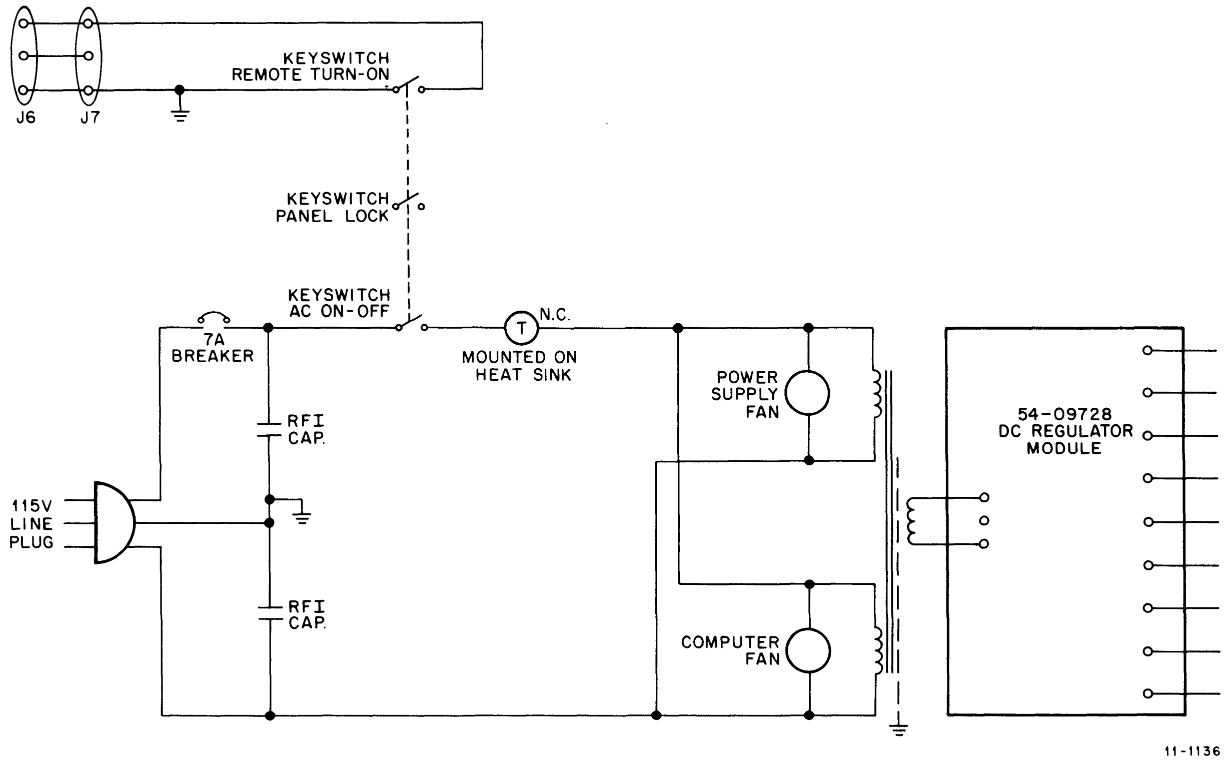


Figure 15-2 115V Connections – Simplified Schematic Diagram

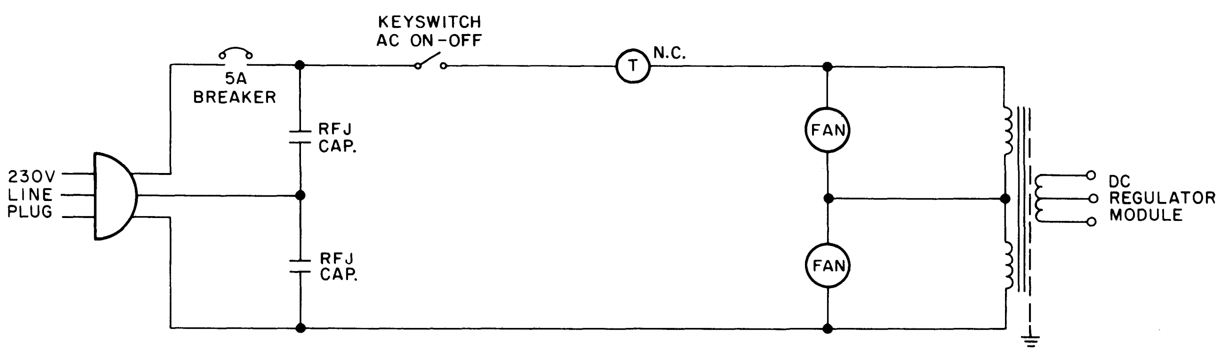


Figure 15-3 230V Connection Diagram

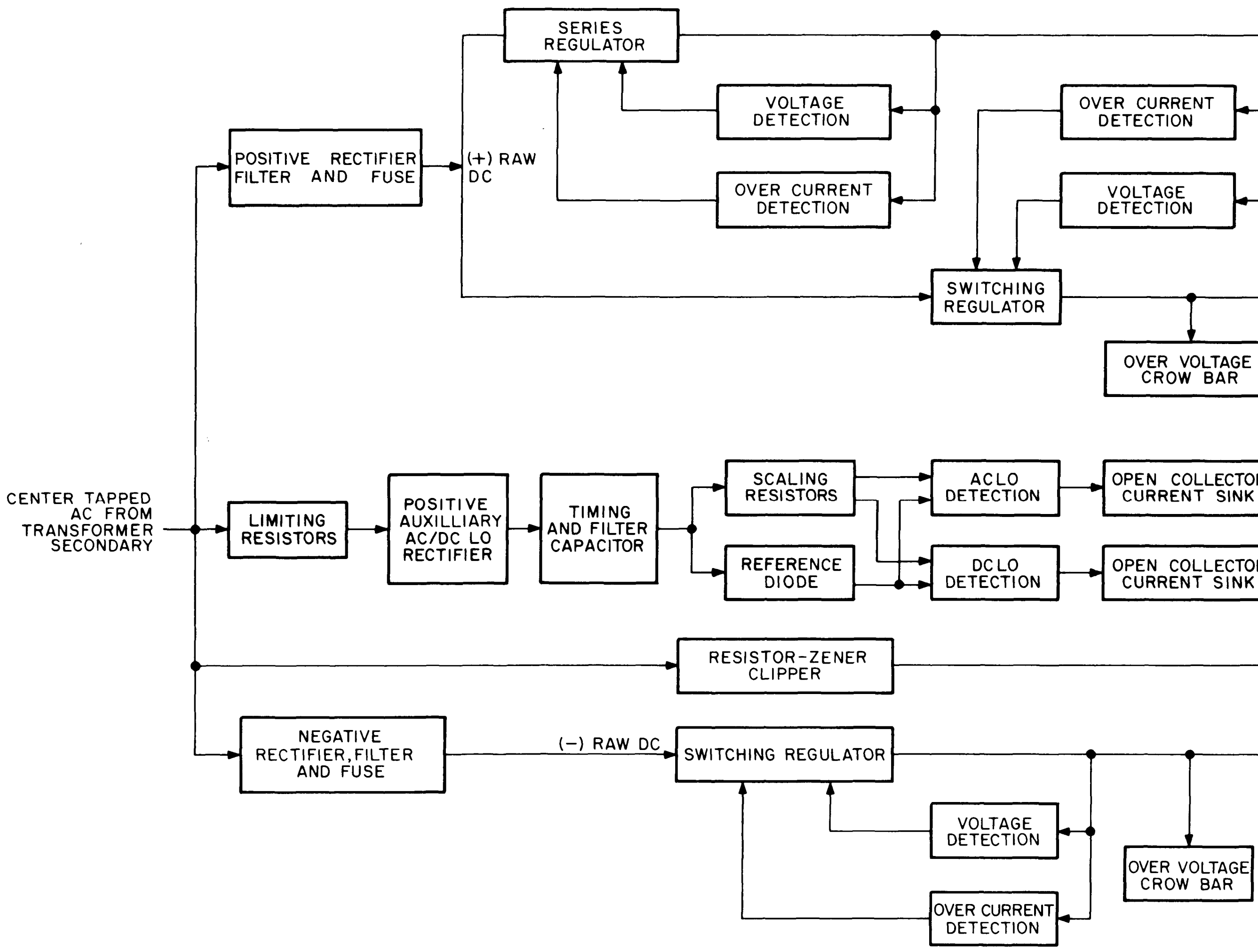


Figure 15-4 Regulator Module Block Diagram

The +28V dc is used by an efficient switching regulator circuit to produce the +5V dc output. Provisions for overcurrent detection are incorporated in the regulator circuit so that excess current is limited when there is a malfunction in the load. The +5V output is also protected against overvoltage by a crowbar circuit which limits the output to under 7V; before the output gets to this value the crowbar circuit blows the fuse in the output circuit of the rectifier.

The −28V dc is used by the −15V circuit, which is similar in operation to the +5V regulator circuit. The −15V crowbar circuit limits the output to 22V.

The LTC L Real-Time Clock synchronizing signal is generated by a simple Zener clipper that is fed from the transformer secondary.

The BUS AC LO L and BUS DC LO L signals are used to warn the Unibus of imminent power failure. Circuits on the regulator module detect the transformer secondary voltage and generate two timed TTL-compatible open-collector signals that are used for power fail functions by devices on the Unibus.

15.3.1 Generation of ±Raw DC

As stated in the previous paragraph, the centertapped transformer secondary voltage is rectified and filtered prior to being fed to the three dc regulators.

The circuitry involved is shown in Figure 15-5. The bridge rectifier D14 is mounted on the heat sink and the input capacitors C1 and C2 are mounted on the bottom of the regulator module. These capacitors filter the input dc and are large enough to provide at least 25-ms storage when the input power is shut off or fails.

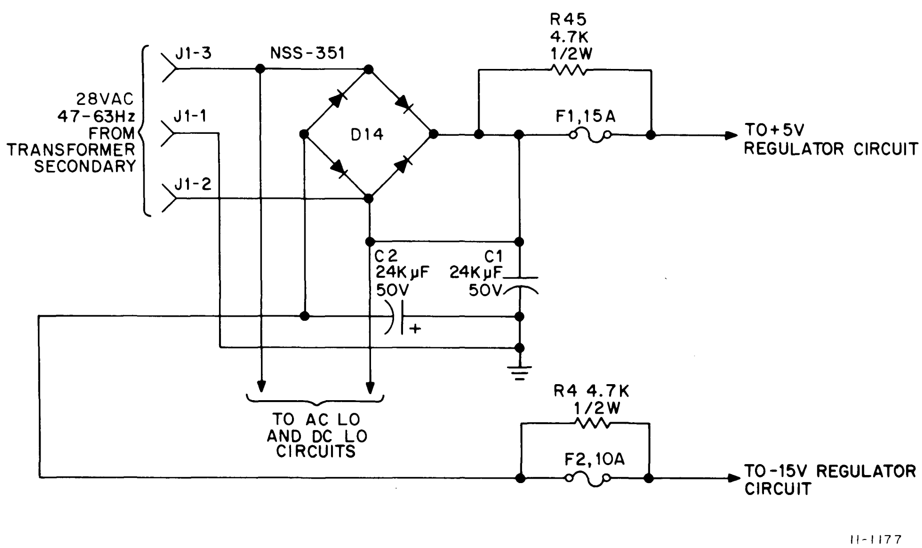


Figure 15-5 Rectifier and LTC L Circuits

A fuse is used on each output to protect the regulator and load during faults. The fuses will not normally blow when a regulator output is shorted because the three outputs are electronically overcurrent protected. However, the appropriate fuse will blow in case of +5V or −15V overvoltage crowbar or in case of failure in one of the overcurrent circuits.

The resistor across each fuse provides a slow (100 - 150 seconds) discharge of C1 or C2 after the power is turned off in case a fuse blows. The capacitors are placed ahead of the fuse to limit the energy in any fault and thus better protect the outputs.

15.3.2 LTC L Circuit

The LTC L Real-Time Clock synchronizing signal (Figure 15-3) is generated by a Zener clipper circuit. The output waveform is a square (clipped sine) wave at line frequency. For one polarity of output sine wave, D13 clips at about +3.9V and in the other polarity D13 clips at its forward voltage of -0.7V.

15.3.3 BUS AC LO L and BUS DC LO L Circuits

The circuitry shown in Figure 15-6 is employed to generate the timed Unibus power status signals specified in Table 14-2. These are used for power fail functions. The transformer secondary voltage is rectified by D1 and D2 and filtered by C9 and R1, R14.

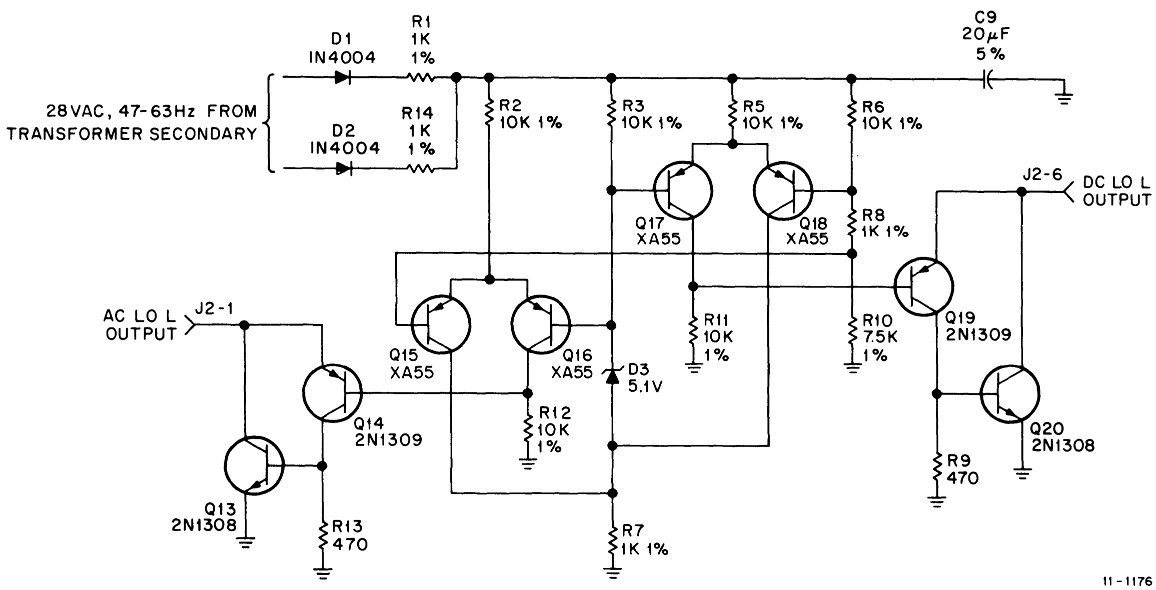


Figure 15-6 BUS AC LO and BUS DC LO Circuits

Circuit parameters are chosen so that the voltage across C9 will rise slower than the three regulated output voltages on power-up, and will decay faster than the three regulated output voltages on power-down.

Two differential amplifier circuits are used to detect power status: C17, Q18 is used to generate BUS DC LO L; and Q15, Q16 is used to generate BUS 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 cathode 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. The status of each differential amplifier is followed by the germanium transistor open-collector output stages Q19, Q20 for BUS DC LO L, and Q13, Q14 for BUS AC LO L. These stages clamp the Unibus at about +0.4V until the differential amplifier circuits sequentially signal them across R11 and R12 that power is up. The outputs then rise to about +5V 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 (+3V)

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

Any time that BUS DC LO L or BUS 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 0.4V 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.

15.3.4 +15V Regulator Circuit

The +15V regulator shown in Figure 15-7 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 in Q1. The +15V 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 more negative (relatively) 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.

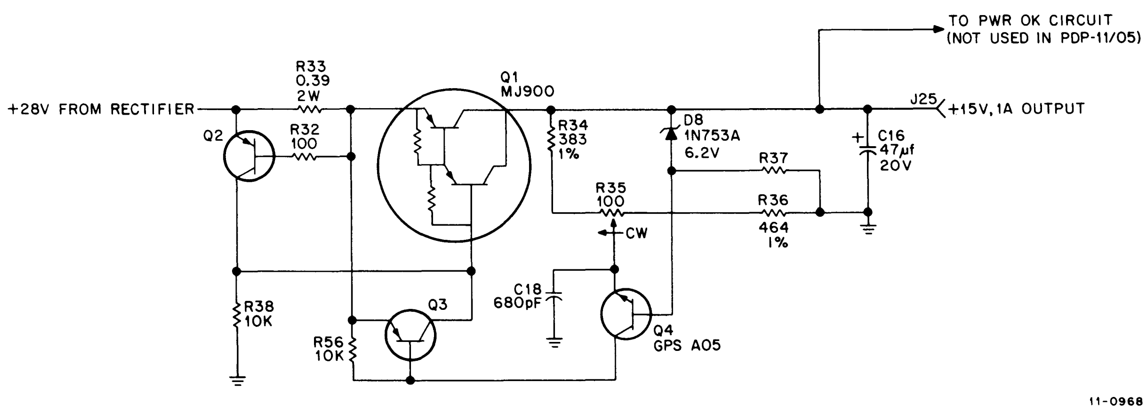


Figure 15-7 +15V Regulator Circuit

R35 acts as the +15V voltage adjustment potentiometer. C18 is a high frequency stabilization capacitor. Q2 is the overload detector; when the output current reaches 1.5A 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.

15.3.5 +5V Regulator Circuit

The +5V regulator is similar to the +15V 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 +5V regulator circuit is shown in Figure 15-8. An over-current circuit is likewise employed.

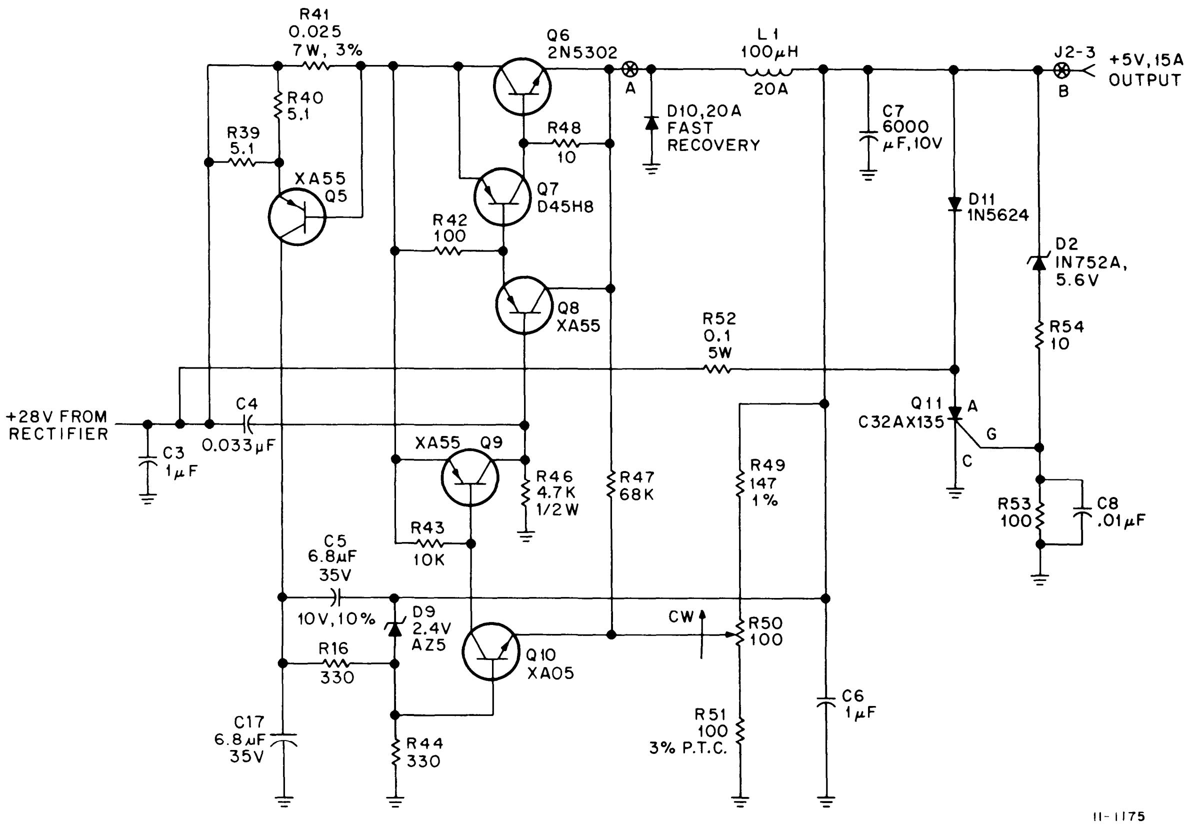


Figure 15-8 +5V Regulator Circuit

The viewing chain consists of R49, 50, 51 and the reference Zener is 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 +15V and +5V 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 +5V 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 30V nominal rectangular pulse train. The filtered output across C7 is thus +5 Vdc 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 and 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 the number 8 power semiconductors to be few.

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 are used on input and output of the regulator, C3 and C6, 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 a malfunction causes the output voltage to increase beyond about 6.8V nominal, Zener diode D2 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.

15.3.6 -15V Regulator Circuit

The -15V regulator circuit is shown in Figure 15-9. It is essentially the complement of the +5V regulator circuit and differs only in minor detail.

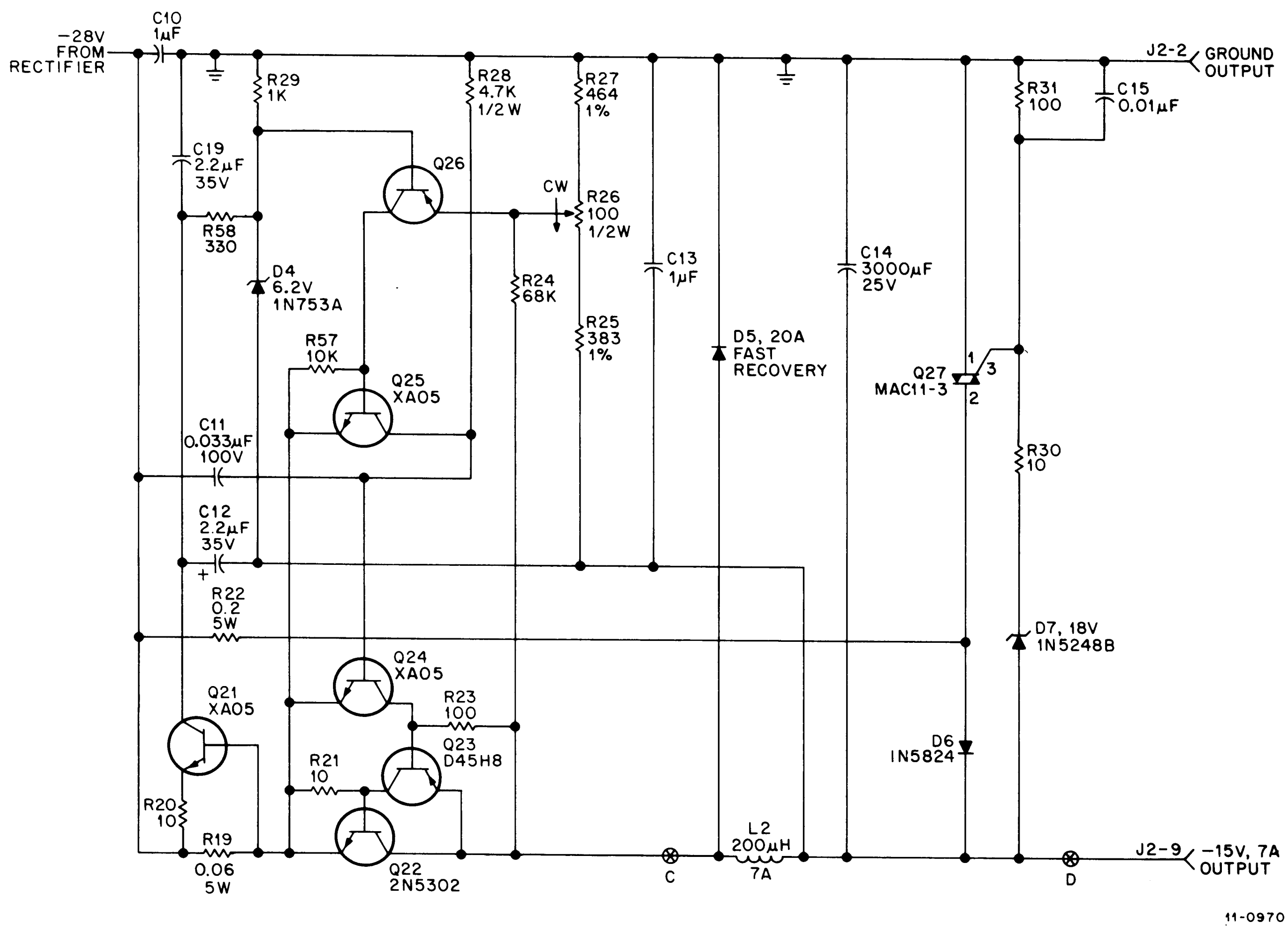


Figure 15-9 -15V Regulator Circuit

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 +15V regulator (Paragraph 15.3.4). The detailed interconnection of the drivers and the circuit values are different. The -15V output voltage is adjusted by potentiometer R26.

CHAPTER 16
POWER SUPPLY MAINTENANCE

16.1 INTRODUCTION

Information is provided in this chapter to maintain the power supply. This consists of adjustments, circuit waveforms, troubleshooting, and parts identification. 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. Finally, the parts identification section provides a directive to obtaining parts information for the entire power supply unit through a parts location directory to the mechanical engineering drawings in the *Engineering Drawing Manual.*

16.2 ADJUSTMENTS

Three adjustments to the power supply adjust the three dc output voltages: +15V, +5V, and -15V. 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 – +15V
b. R50 – +5V
c. R26 – -15V

In performing any of these adjustments note the following:

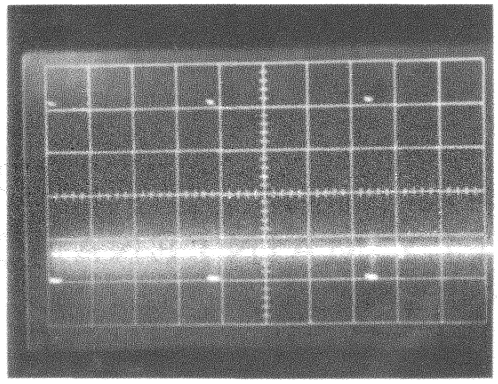
CAUTION

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

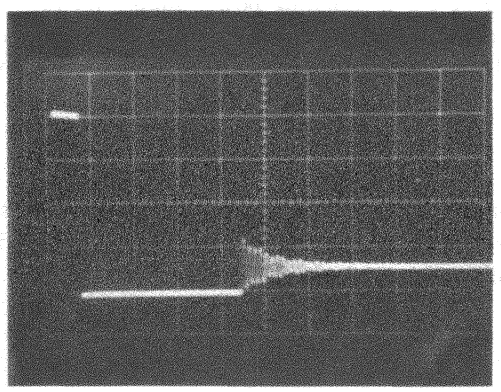
2. **Do use a calibrated voltmeter; preferably a digital voltmeter. Voltages should be adjusted to their center values: +15.0, +5.0, and -15.0, all under load at the dc cable termination on the system unit.**

16.3 CIRCUIT WAVEFORMS

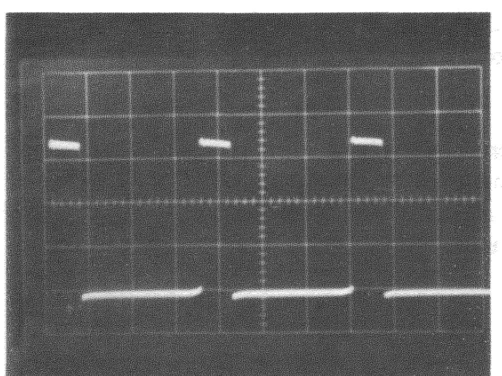
The two basic regulator circuits used on the dc regulator module generate +5V and -15V. Figure 16-1 shows six waveforms of the +5V regulator circuit taken at two points (A and B) in the circuit (Figure 14-6). Waveforms a, b, and c are taken at point A, which is the +5V circuit, Q6 transistor output. Waveforms d, e, and f are taken at point B, which is +5V power supply output (J2-3). Figure 16-1 also indicates the load conditions and time scales for each waveform. Figure 16-2 shows six waveforms of the -15V regulator circuit taken at two points (C and D) in the circuit (Figure 14-7). Waveforms a, b, and c are taken at point C, which is the -15V power supply output (J2-9). The load conditions and time scales of the respective waveforms are indicated in Figure 16-2. These waveforms were taken on a Tektronix Model 453 Oscilloscope. All waveforms are with respect to J2-2, power common.



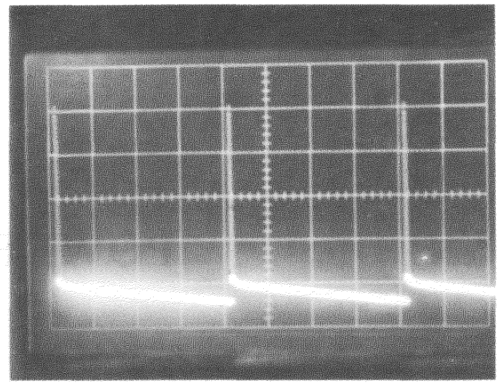
a) Point A, No load,
2 ms /div, and
10V/div.



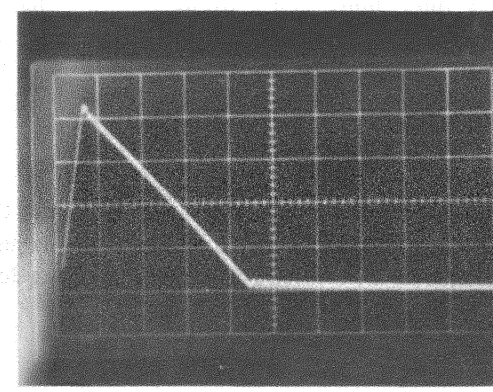
b) Point A, No load,
20 μs/div, and
10V/div.



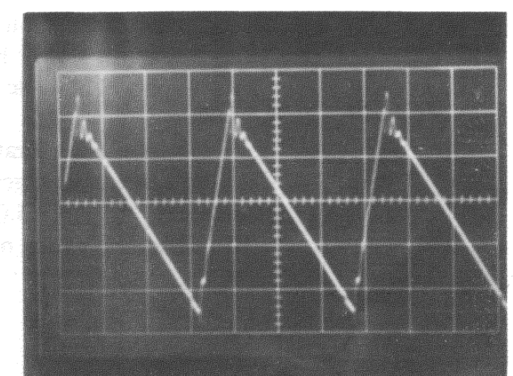
c) Point A, 20A load,
20 μs/div, and
10V/div.



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

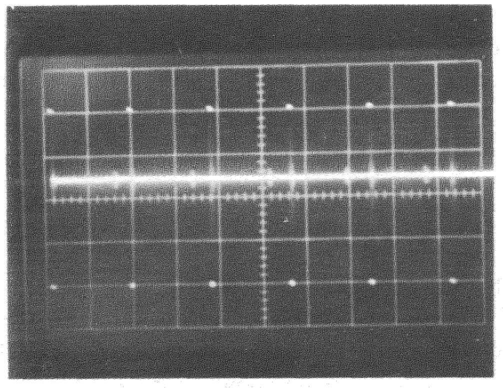


e) Point B, No load,
20 μs/div, and
50 mV/div.

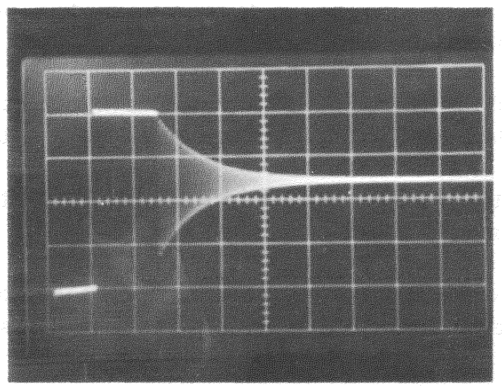


f) Point B, 20A load,
μs/div, and
50 mV/div.

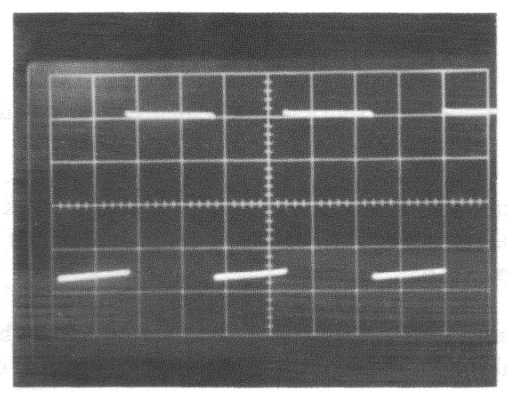
Figure 16-1 +5V Regulator Circuit Waveforms



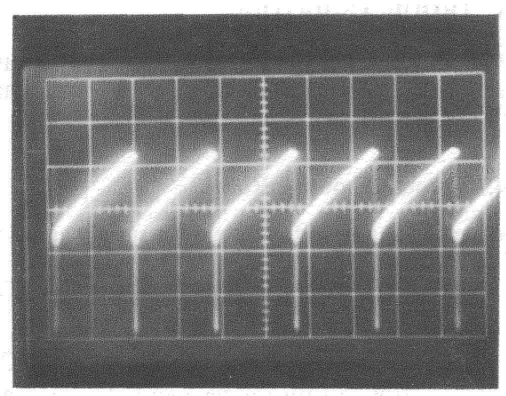
a) Point C, No load,
5 ms/div, and
10V/div.



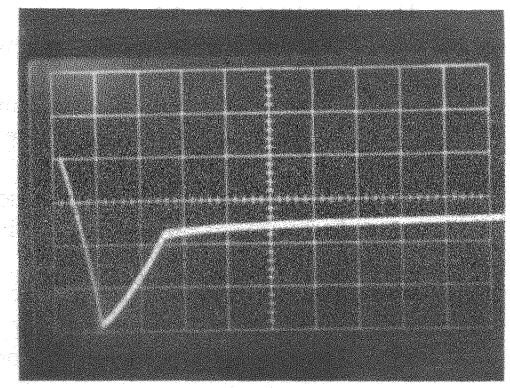
b) Point C, No load,
50 μs/div, and
10V/div.



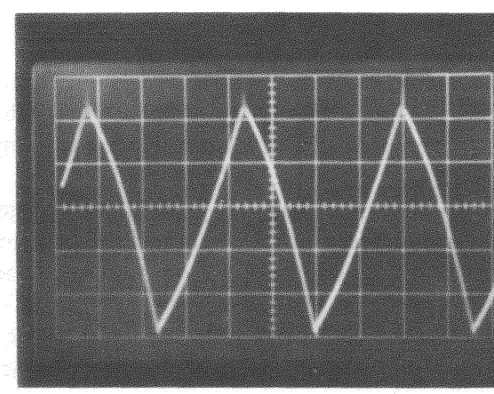
c) Point C, 5A load,
50 μs/div, and
10V/div.



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 16-2 −15V Regulator Circuit Waveforms

16.4 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 (drawing D-CS-5409728-0-1).

16.4.1 Troubleshooting Rules

Troubleshooting rules for the power supply are as follows:

a. Make certain that power is turned off and unplugged before servicing the power supply.

b. Ensure that input capacitors C1 and C2 are discharged before servicing the power supply. A 10 to 100Ω, 10W 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 after disconnecting the dc output cable to the system unit.

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 inch-pounds (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 computer chassis. 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 #128 compound or Dow Silicon Grease to the heat sink contact side (bottom) of the semiconductor. Insulating wafers are not required.

16.4.2 Troubleshooting Hints

CAUTION
Unplug computer before servicing.

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

The +5V and −15V regulators contain overvoltage detection circuitry. If R50 or R26 are 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 16.2.

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.

16.4.3 Troubleshooting Chart

In checking the various areas of the power supply, the rules listed in Paragraph 16.4.1 should be followed. The waveforms referenced in Paragraph 16.3 provide a comparison for the troubleshooting readings. Table 16-1 provides the dc regulator troubleshooting chart.

Table 16-1
Troubleshooting Chart

Problem	Cause
No +5V and +15V output	F1 opened* D14 or transformer opened* +5V adjusted too high*
+5V 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
+15V Output Too High	Q1 shorted E8 opened R35 or R36 opened
No -15V Output	F2 opened D14 or transformer opened
-15V Output Too Low	-15V adjusted too high* Q25, D4, Q26, Q21, Q27, D7 or D5 shorted C14 or C12 shorted R22, R26, R25, or R29 opened
	Q22, Q23, Q24, or D6 shorted Q25, Q26, or D4 opened
BUS AC LO L Will Not Go High	Q13, Q14, or Q15 shorted Q16 or D3 opened R7, R3, R6, or R8 opened C9 shorted
BUS 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
BUS DC LO L Will Not Go High	Q19, Q20, or Q18 shorted Q17 or D3 opened R7, R2, or R6 opened C9 shorted
BUS DC LO L Will Not Go Low	Q19, Q20, of Q17 opened Q17 or D3 opened R7, R3, or R6 opened C9 shorted

*These causes make the crowbar fire, which in turn, blows the appropriate fuse.

Table 16-1 (Cont)
Troubleshooting Chart

Problem	Cause
BUS 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

16.5 PARTS IDENTIFICATION

Parts identification for the power supply is provided in the *Engineering Drawing Manual.* This includes the assembly drawings with associated parts lists, which list the respective unit parts, their part designation, and their DEC part numbers. These drawings and the respective drawing numbers are as follows:

a. Power Supply Chassis: E-1A-5309816-0-0

b. Power Control Board 115V: C-IA-5409824-0-0
230V: C-IA-5409825-0-0

c. DC Regulator Module: E-IA-5409728-0-0
D-CS-5409728-0-1 (schematic)

d. Power Supply Assembly and Fan: D-AD-7003731-0-0

e. AC Input Box Assembly: D-UA-H400-0-0

f. Line Set 115 Vac 7A: C-UA-BC05H-0-0
230 Vac 5A: C-UA-BC05J-0-0