SECTION V

POWER SUPPLIES

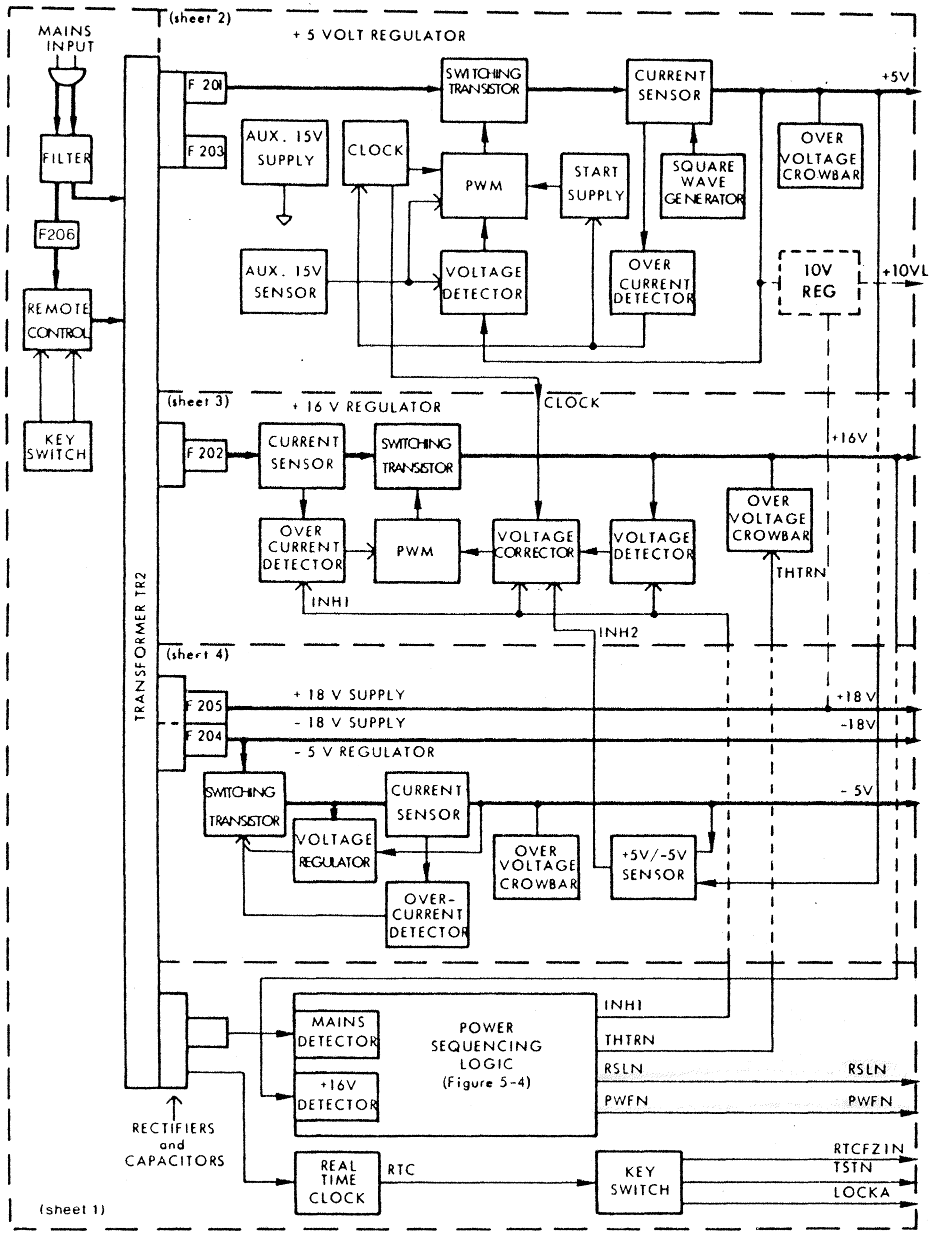
5.1 GENERAL

Each basic chassis contains its own power supply (Table 4-1). The power supply with the M4 chassis provides regulated +5V at 43 amps, +16V at 9 amps, and -5V at 2 amps, as well as unregulated +18 and -18 volts at 2 amps each. The M5 chassis contains two power supplies : one identical to the M4 supply, and a second supply that differs only in some component positions. The main power and logic signals of the basic supply are shown in the block diagram, Figure 5-1. The mechanical configuration and parts locations are shown in Figures 5-6 through 5-9.

5.2 INPUTS

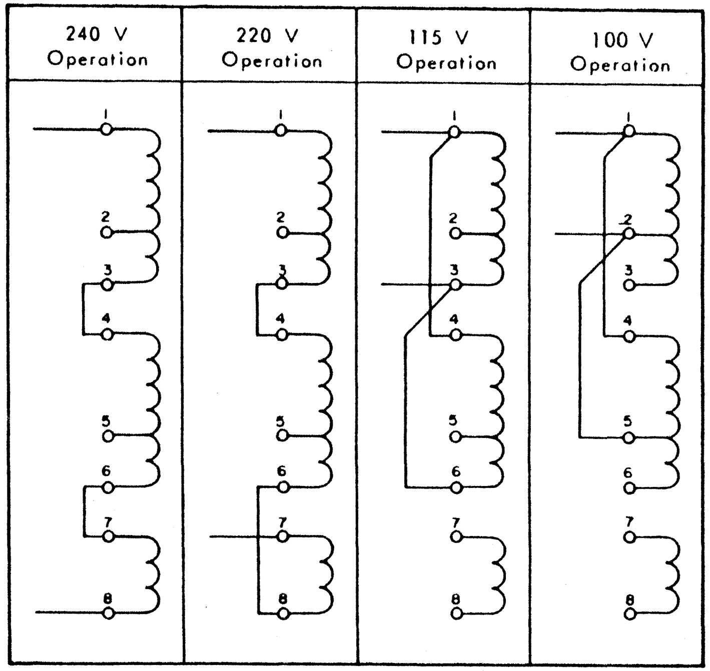
The power supply operates on voltages of 100V, 115V, 220V, or 240V, ±10 %, single phase, at either 50 Hz (± 2 Hz) or 60 Hz (± 3 Hz). The power supply is adapted to the selected input voltage by wiring the input-side of the mains transformer, T201, as shown in Figure 5-2. The transformer input connections and jumpers are made by individual plugs at the rear of the chassis (Figure 5-7). The AC input is filtered, fused, and then switched by means of a remote-control circuit. The remote-control circuit (Figure 5-3, sheet 1) is located on printed-circuit card P1.

5.3 A battery connection is provided on the power supply chassis. The purpose of an external battery supply is to maintain the +16V and part of the +5V supplies during a mains power failure. The battery connector wiring is shown on Figure 5-3, sheet 1.



Notes - The dashed-line sections show the locations on schematic diagram Figure 6-18
The arrows ➡ show normal flow.
The arrows → show the inhibit/enable signals.

Figure 5-1 P857 Power Supply Block Diagram



Point 9 of the transformer is a shield between primary and secondary windings. The shield must be connected to the ground.

The fan is connected on the first 115V winding (1-3) so that it is always supplied with 115V.

Figure 5-2 Mains Input Wiring

5.4 OUTPUTS

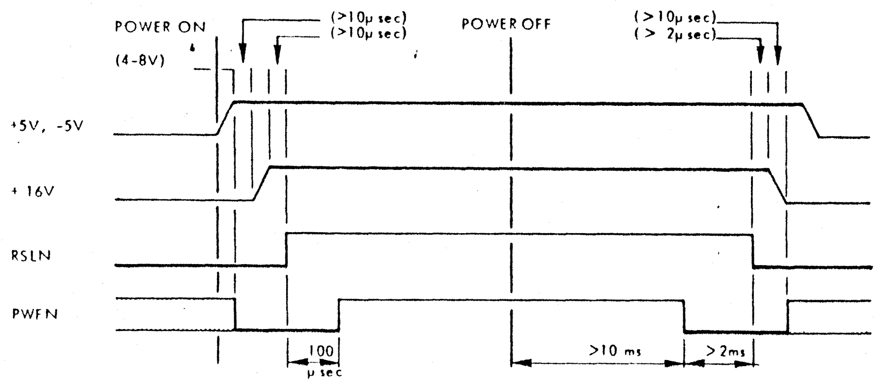
The output voltages, and maximum currents from this supply are:

- +16V, 9A, ±3% (due to ±10% mains and load variation)
- + 5V, 43A, } ±2% (due to ±10% mains and load variation) ±2% for ripple and noise, p-p from 0 to 20 MHz.
- - 5V, 2A, }
- +18V, 2A, } -10%, +70% (non regulated)
- -18V, 2A, }
- +10V, 1A, ±3% (due to ±10% mains and load variations)

The +16V supply is used by the memory (inhibit amplifiers). About 9 amps are required for 32k words of memory; the 16V, 9-amps supplies 64k words of memory with two modules working at the same time, with interleaving. The -5V supply is used by memory (about 1.5 amps) and by the interface drivers for the big disc control unit (about 1 amp). The unregulated +18V and -18V supplies are used by data-communication and teletype control units; the 18 volts are converted to 12 or 6 volts by regulators on the control-unit cards. The +5V supply is used by the CPU logic.

5.5 LOGIC SIGNALS

The RSLN (Reset Line) and PWFN (Power Failure) signals are used for power on/off sequences and automatic restart. The full logic description is given in paragraph 2.45. The power supply controls both signals with the following timing :



The power-off sequence is shown for switching off or for a power failure greater than 10 ms. Shorter line failures will not cause the "off" sequence. Once PWFN goes active (low), the sequence must continue to activate RSLN.

5.6 REAL TIME CLOCK

The Real Time Clock (RTC) is a 1us pulse every 20ms which is sent to the RTCF flip-flop (program status bit 12) to be used as an internal interrupt. The RTC pulse is generated by pulse-shaping the mains frequency. The RTC pulse is then sent via the control-panel key switch (positions ONRTC and LOCK) to the CPU logic RTCF flip-flop (Figure 2-8 PP). The operation of the General Flip-Flop (GF) RTCF is described in Section II. The RTCF interrupt is also shown on the Interrupts and Breaks diagram in Section I.

5.7 FUSES

The power supply contains one fuse in the mains input (F206) and additional fuses for the supplied voltages. The fuses for the supplied voltages (at the rectifier/filter outputs) are to protect the rectifiers and transformer in case of regulator failure; the regulators themselves are electronically protected. The power supply fuses are listed in the following table :

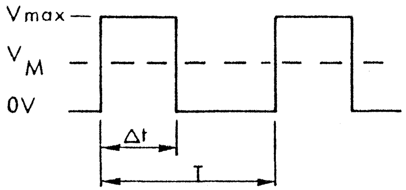
Fuse	Purpose	Schematic	Location
F206	Mains input, slow operating : 4 amp for 220V/240V inputs 8 amp for 100V/115V inputs	sheet 1	
F101	0.1 amp, mains detector	sheet 1	
F201	20 amp, +5V regulator	sheet 2	
F202	10 amp, +16V regulator	sheet 3	
F203	2 amp, auxillary 15V supply for the power-supply circuits.	sheet 2	
F204	3.15 amp, -18V and -5V supplies	sheet 4	
F205	3.15 amp, +18V supply	sheet 4	

5.8 RECTIFIER CIRCUITS

The inputs to all of the DC supplies use center-tapped, full-wave rectifiers. The AC voltage is supplied by five center-tapped secondary windings of transformer TR2. The rectifier circuits are shown on the schematic diagram (Figure 5-3) with their appropriate supplies. The +5V and +16V regulators take the positive voltage from the transformer center taps, which allows the anodes of the high-current diodes to be mounted in heat sinks at zero volts (ground). The +18V and -18V supplies use a full-wave bridge package, but each supply is using only two diodes of the bridge together with the center-tapped transformer winding. The -5V regulator takes its input voltage from the unregulated -18V supply.

5.9 +5V REGULATOR

5.10 Voltage Regulation. The +5V, 43-amp power is supplied by a switching type regulator (Figure 5-3, Sheet 2). High efficiency is obtained because of the regulator transistors (Q201, 202, and 203) being always on or off. The regulator transistors are controlled by a voltage detector and a voltage corrector. The switching frequency is controlled by an independent clock circuit common to the +5 and +16 volt supplies, and is thereby not load-dependent.
The +5V regulator controls the mean voltage V_M (following diagram) by varying the switch-on time in direct relation to the required correction.
The Δt is reduced, while the switching frequency is held constant, in order to reduce the mean output voltage.



$$\frac{V_M \searrow}{V_{max}} = \frac{\Delta t \searrow}{T}$$

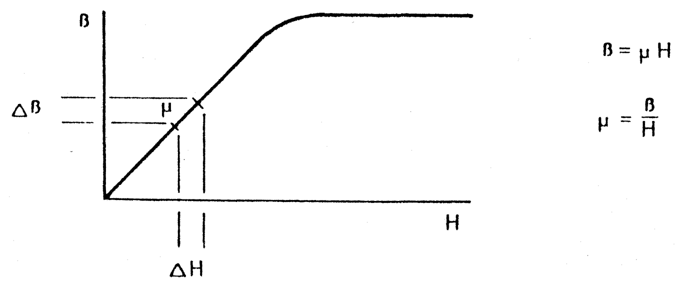
5.11 The switching regulation operates at a frequency (20 KHz, ±5%) determined by the type 555 clock circuit, IC1. The clock provides a timing input to voltage corrector IC2. IC2 is a type 555 pulse-width modulator (PWM) which generates a pulse to switch regulator Q201/2/3 on and off. Regulation is provided by the variable pulse width from IC2. When Q201/2/3 switches on, current flows through inductor L203 to the load, increasing linearly, and charges the output capacitors. When Q201/2/3 switches off, L203 current starts to decrease, and diodes CR201/2 are forward biased; the current now flows through CR201/2, decreasing linearly.

5.12 The +5V output sense voltage is compared to a reference voltage by error amplifier IC4. (Since the type uA723 reference voltage is about 7 volts, the +5V supply (< 7V) adjusts the reference level.) As the sense voltage increases, the output current at IC4, pin 9 increases and the Q8 collector voltage to PWM IC2 decreases. The reduced threshold voltage at pin 5 of IC2 decreases the pulse width output from the voltage corrector. The narrower pulse to Q201/2/3 (via transformer T1) results in less "on time" for the regulator transistors, and reduces the final output voltage.

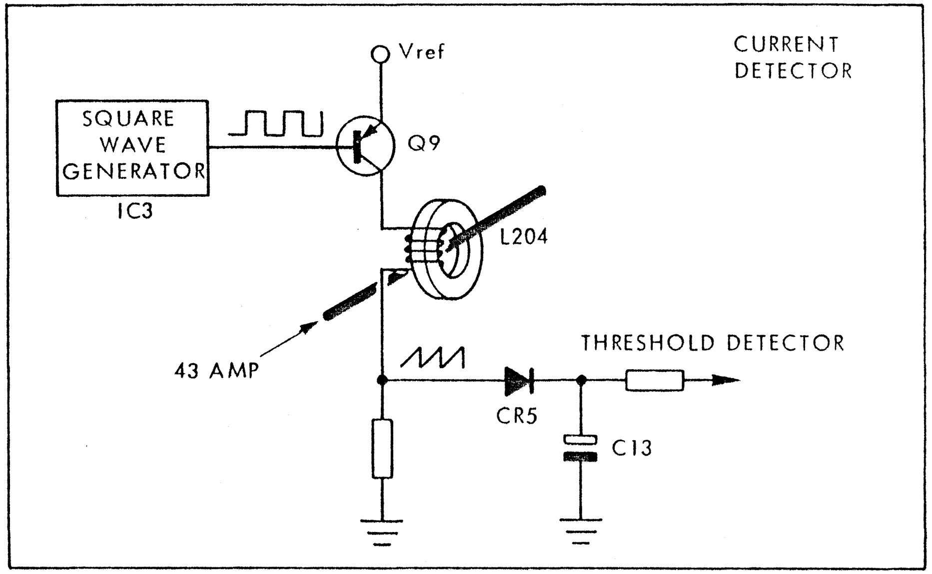
5.13 The 1:1 transformer T1 is used to couple the high-current supply with sensitive, low-current control circuits. This allows higher-voltage regulation control with resultant higher efficiency and higher-speed operation for the voltage regulation. The coupling transformer is supplied with 3.5 volts at high current during power-on time by starting-supply IC5, Q12. Once the +5V supply is up, T1 is supplied by the +5 volts via diode CR1; the emitter of Q12 is back-biased and the starting supply is held off. The starting supply is inhibited (along with the clock) by an overcurrent cutoff.

5.14 Overvoltage Crowbar. An overvoltage detection circuit (crowbar) for the +5V supply is made up of a threshold detector (Q101) and thyristor (CR101). If the supply output voltage increases beyond the nominal value, between 6 and 7 volts, Q101 switches on and the thyristor fires to short-circuit the supply.

5.15 Overcurrent Detection. Current detection on this 43-amp supply is performed by passing the +5V line through the center of a variable-μ ferrite core (L204) which has a sensing coil wound about it. Direct current through the +5V line produces a magnetic field (H) which causes a magnetic flux in the core. The flux density (B) and the properties of the core material determine the permeability (u) of the core; thus, any change in the current through the core (I) changes the field strength (H) which changes the permeability (u).



5.16 A type 555 square-wave generator (IC3, Q7, Q9) produces a voltage square wave which passes through the L204 coil (from pin A to B) to the over-current detector (IC6). The inductance (L) of the coil retards the leading edge of the squarewave to produce a current sawtooth output to the detector (following diagram). Since the inductance of the coil (L) is approximately $L = u\ N^2$ (where N is the number of turns, a constant), a change in u causes a change in the sensing current through the coil (ΔI). The height of the sawtooth is thus directly dependant on the coil's L, as follows : $E = L\ \Delta I / \Delta T$, with ΔT and E constants from the squarewave generator. Excess current therefore increases the amplitude of the sawtooth sufficiently to trigger the threshold detector at the IC6 input.



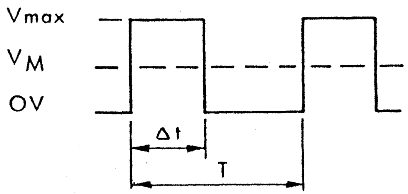
5.17 When overcurrent detector IC6 is triggered, it produces an inhibit signal which blocks the T1 starting supply and the clock. With the clock (IC1) stopped, the +5V and +16V supplies are blocked. The starting supply to T1 must be inhibited separately because it derives its power from the unregulated part of the +5V supply which is not stopped when the IC1 clock stops.

5.18 When the +5 volts is off, the squarewave output is off and transistor Q9 is on. Since the L204 coil is short for DC, the threshold detector detects a constant high and adds to the shut off condition. Negative spikes (caused by L) are removed from the Q9 squarewave output by zener diodes CR14 and CR15. The resistors shown as part of L204 are selected during manufacture to produce the same u for all units. The relationship from current (I) to squarewave voltage is :

$$\underset{\uparrow}{I} \rightarrow \underset{\uparrow}{H} \rightarrow \underset{\downarrow}{u} \rightarrow \underset{\downarrow}{L} \rightarrow \underset{\uparrow}{\Delta I} \rightarrow \underset{\uparrow}{\Delta E}.$$

5.19 +16V REGULATOR

5.20 Voltage Regulation. The +16V, 9-amp power is supplied by a switching type regulator (Figure 5-3, Sheet 3). High efficiency is obtained because regulator transistor Q204 is always on or off. The regulator transistor is controlled by a voltage detector and a voltage corrector. The switching frequency is controlled by an independent clock circuit common to the +5 and +16 volt supplies, and is thereby not load-dependent. The +16V regulator controls the mean voltage V_M (following diagram) by varying the switch-on time in direct relation to the required correction. The Δt is reduced, while the switching frequency is held constant, in order to reduce the mean output voltage.



$$\frac{V_M\downarrow}{V_{max}} = \frac{\Delta t\downarrow}{T}$$

5.21 The switching regulation operates at a frequency (20 KHz) determined by the type 555 clock circuit, IC1. The clock provides a timing input to voltage corrector IC9. IC9 is a type 555 pulse-width modulator (PWM) which generates a pulse to switch regulator Q204 on and off. Regulation is provided by the variable pulse width from IC2. When Q204 switches on, current flows through inductor L202 to the load, increasing linearly, and charges the output capacitors. When Q204 switches off, L202 current starts to decrease, and diode CR203 is forward biased; the current now flows through CR203, decreasing linearly.

5.22 The +16V output sense voltage is compared to a reference voltage by error amplifier IC8. (Since the type uA723 reference voltage is about 7 volts, the +16V supply (>7V) adjusts the sense level.) As the sense voltage increases, the output current at IC8, pin 9 increases and the Q19 collector voltage to PWM IC9 decreases. The decreased threshold voltage at pin 5 of IC9 decreases the pulse width output from the voltage corrector. The narrower pulse to Q204 (via Q20 and Q13) results in less "on time" for the regulator transistor, and reduces the final output voltage.

5.23 Overvoltage Crowbar. An overvoltage detection circuit (crowbar) for the +16V supply is made up of a threshold detector (Q102) and thyristor (CR103). If the supply output voltage increases beyond the nominal value, between 16.8 and 20.3 volts, Q102 switches on and the thyristor fires to short-circuit the supply. The THTR signal is used to shut off the 16-volt supply during the power-off sequence (paragraph 5-41).

5.24 Overcurrent Detection. Current sensing in the +16V supply is performed by resistor R207 in series with the supply. The lower-voltage half of R207 is used as a reference at the pin-4 input of error amplifier IC7. This reference voltage is held constant by zener diode CR8, and an adjustment is provided by trimpot PR4. The higher-voltage half of R207 is used as a sense input at IC7, pin 3. Zener diode CR10 is used to reduce the sense-input voltage. An increase in current through R207 will increase the sense voltage (developed across R45) in relation to the reference voltage. The resultant high output from IC7, pin 2, via Q15, will gate on thyristor CR13 and shut off the +16 volt supply.

5.25 Inhibit Signals. The inhibit signal INH1 delays operation of the +16V regulator during initial power-on time to produce a slow rise of the +16 volts. INH1 is active (high) for approximately 300 ms after power on (Figure 5-5). During this initial delay time, the overcurrent detector is blocked via Q17 and the overvoltage circuit is blocked via Q16 and Q18.

5.26 The inhibit signal INH2 blocks the +16V regulator if either the +5 volts or -5 volts are not present. Loss of either voltage drops out relay K102 (Figure 5-3, Sheet 4) which then grounds the output of the overvoltage corrector circuit (sheet 3).

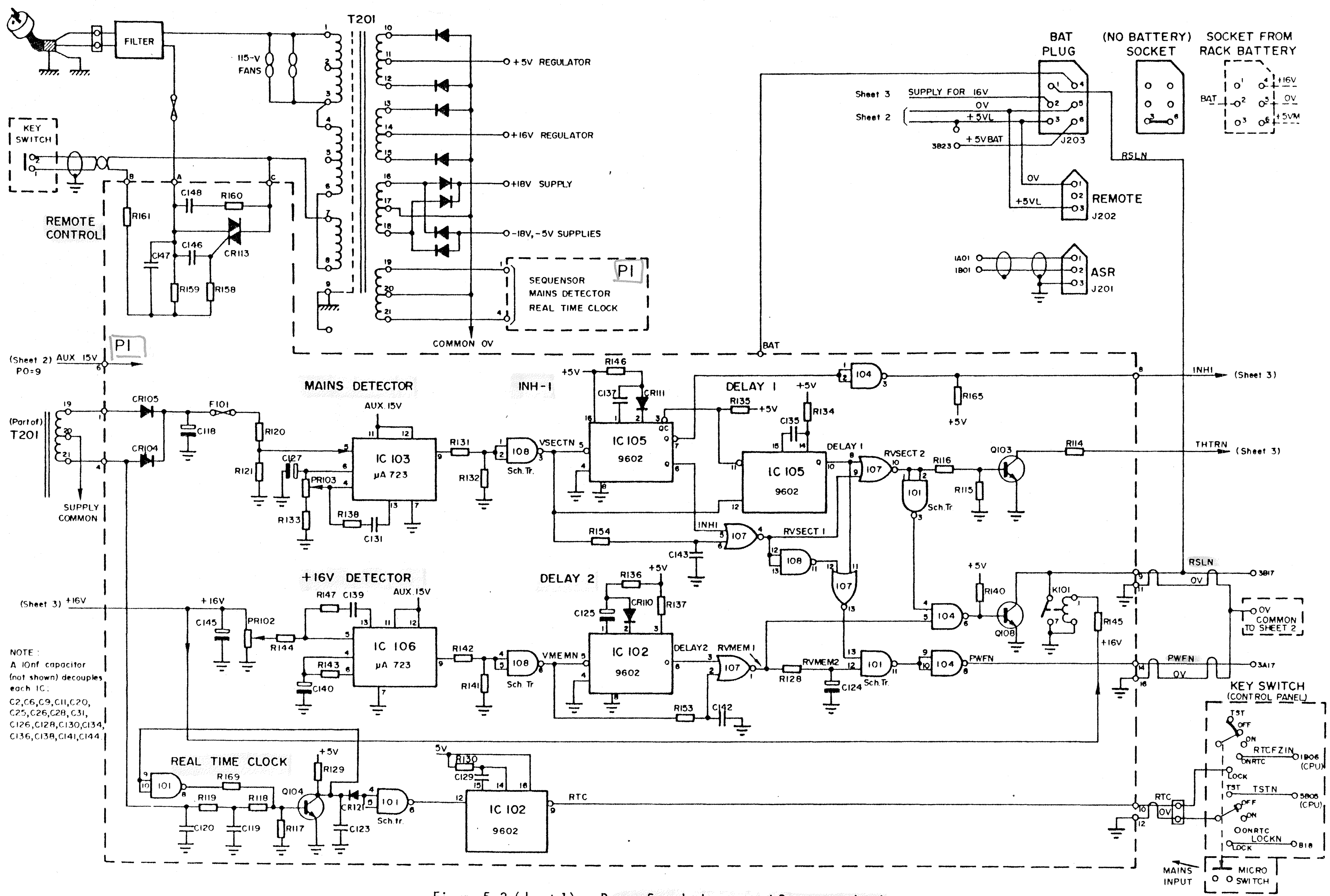
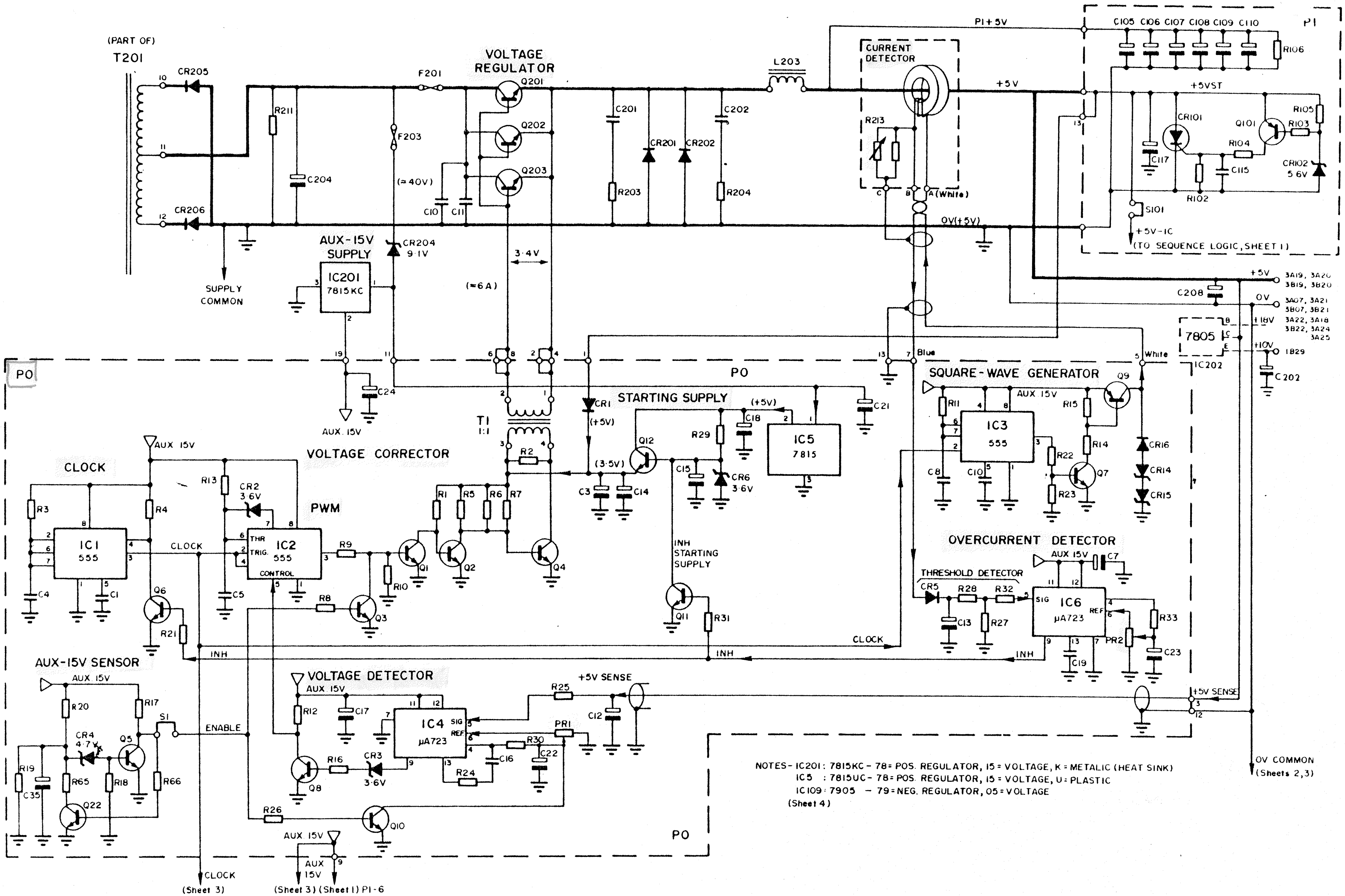


Figure 5-3 (sheet 1) Power Supply Inputs and Sequensor Logic

P1 lower PCB



NOTES - IC201 : 7815KC - 78 = POS. REGULATOR, 15 = VOLTAGE, K = METALIC (HEAT SINK)
IC5 : 7815UC - 78 = POS. REGULATOR, 15 = VOLTAGE, U = PLASTIC
IC109 : 7905 - 79 = NEG. REGULATOR, 05 = VOLTAGE
(Sheet 4)

Figure 5-3 (sheet 2) Power Supply +5V Regulator

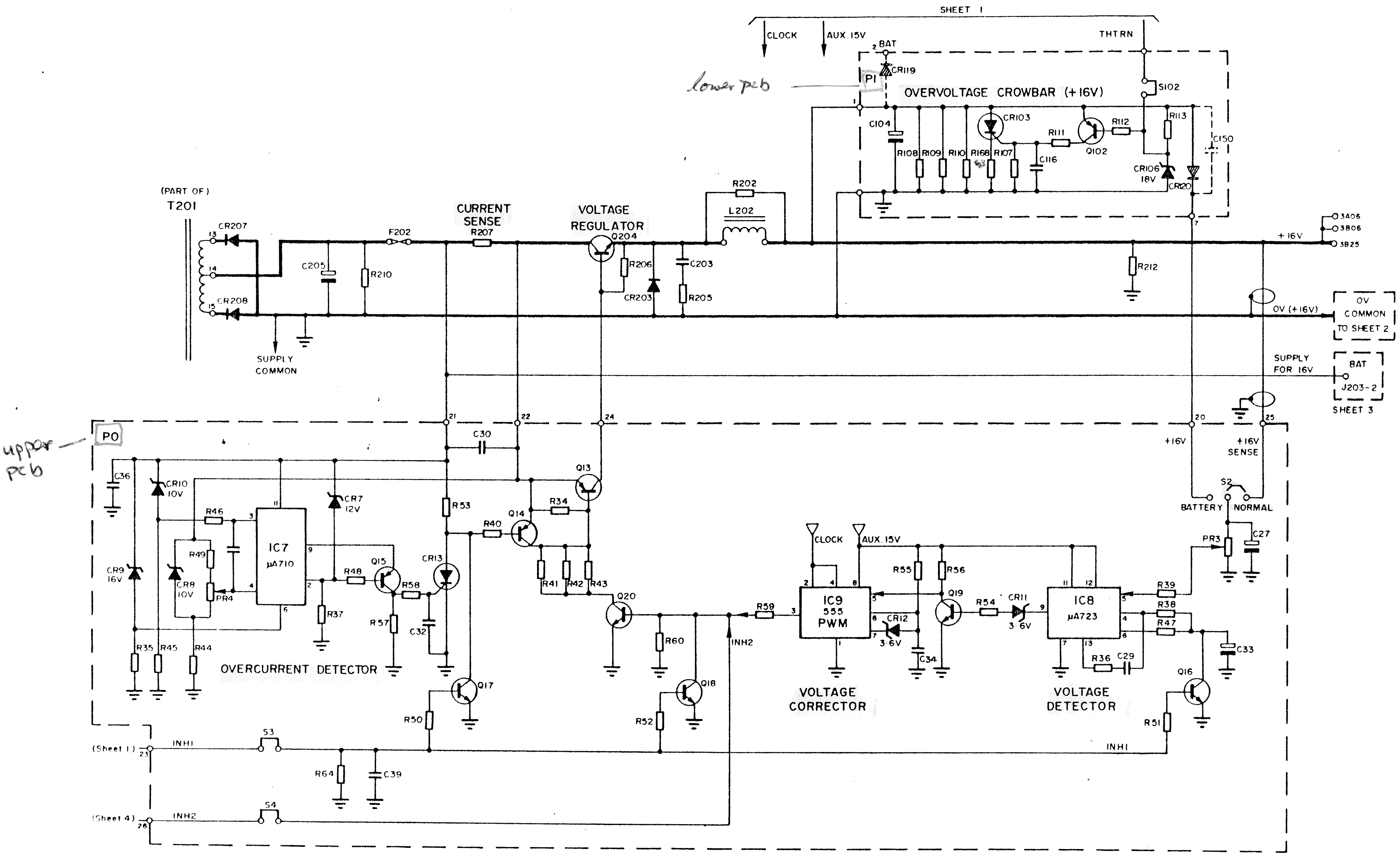


Figure 5-3 (sheet 3) Power Supply +16V Regulator

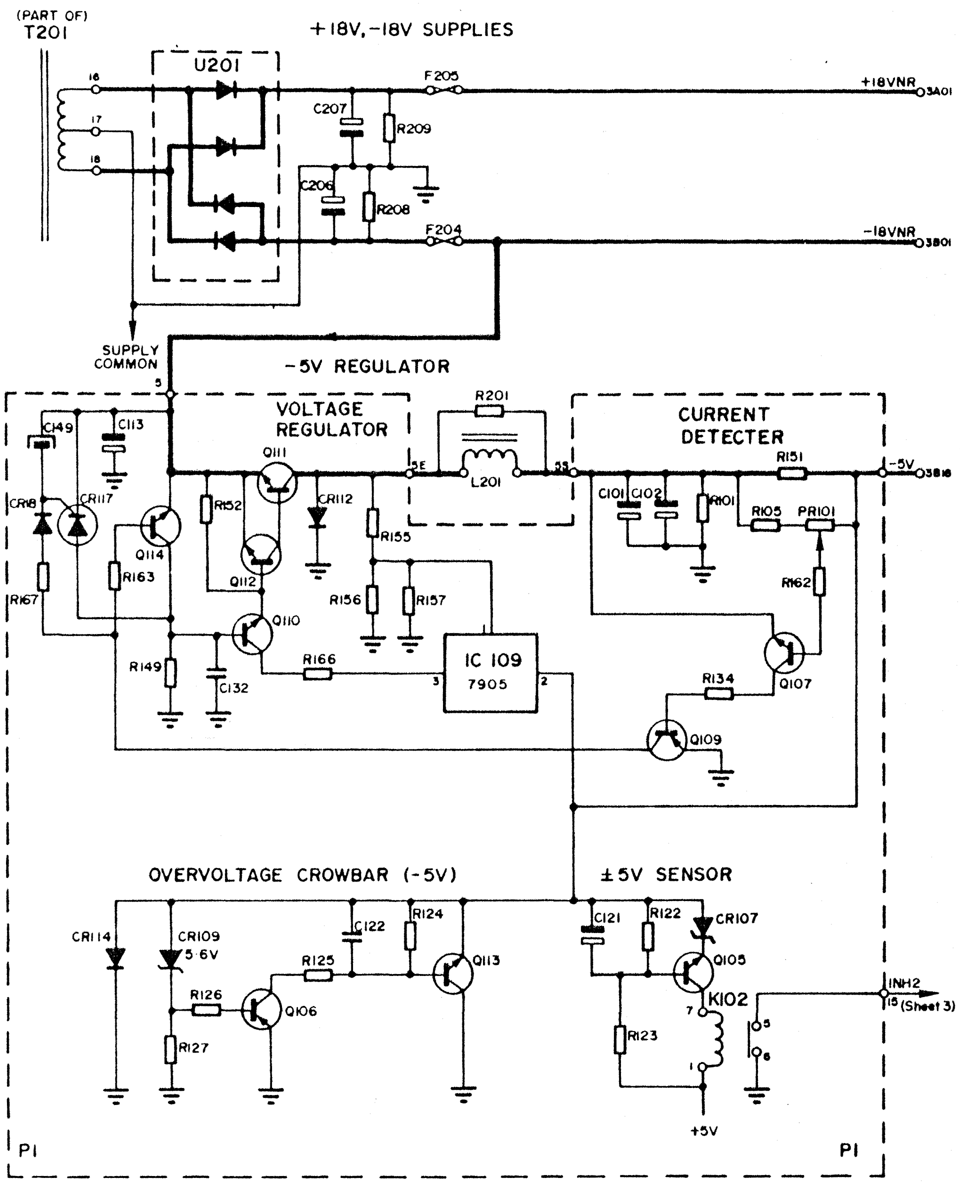


Figure 5-3 (sheet 4) Power Supply +18V, -18V, -5V Supplies

5.27 +10V REGULATOR

The +10V supply for the LOC MOS circuits of the CPU is provided by a series integrated regulator type 7805. It is connected between the +5V and +18V supply lines and provides +10V at a maximum current of 1 ampere which is limited by a circuit within the chip. (See Figure 5-3, sheet 2.)

5.28 Connection for an External Battery Rack

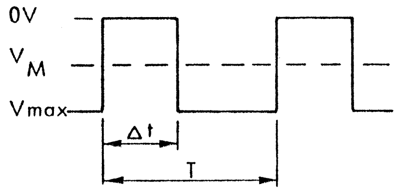
When core memory or both core and MOS memories are used by the CPU an External Battery Rack is not needed and it is dangerous to make such a connection. When only MOS memories are used an External Battery Rack must be connected if the contents of the memories are to be maintained during power failures. Also alterations must be made to the connections of the +16V and S+16V lines as follows:

- Change the position of the U link S2 (Figure 5-3 sheet 3) from NORMAL to the BATTERY position.
- Disconnect the +16V lead on pin 1 of the P1 card and connect it to pin 2 (BAT) on the same card (Figure 5-3 sheet 3).

It is dangerous to use core memories in this configuration because the value of the +16V is increased. When no battery rack is fitted a dummy socket is inserted in the battery plug of the power supply to make the +5VL to +5VM connection (Figure 5-3 sheet 1).

5.29 -5V REGULATOR

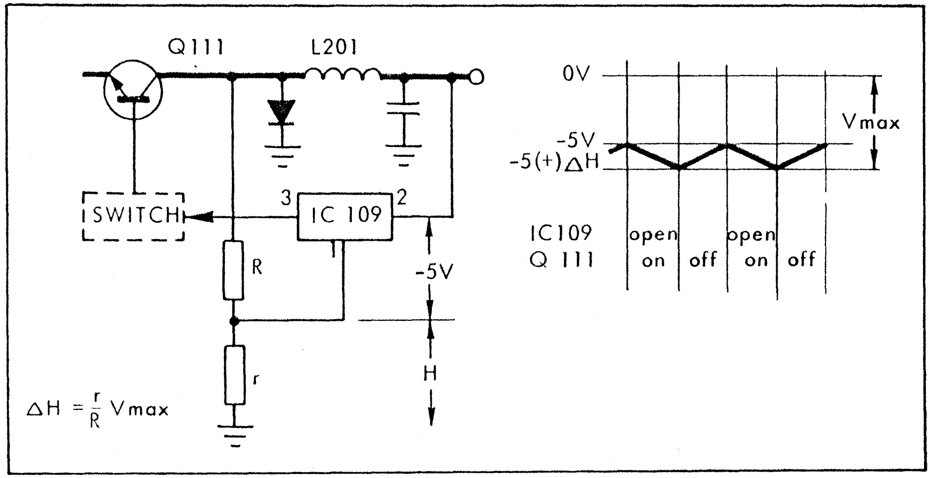
5.30 Voltage Regulation. The -5V, 2-amp power is supplied by a switching type regulator (Figure 5-3, Sheet 4). Transistor Q111 is switched on and off at about 20 kHz by a type 7905 regulator (IC109) used as the voltage detector. The -5V regulator controls the mean voltage V_M (following diagram) by varying the switching frequency T in inverse relation to the required correction. The T is increased, while the on-time Δt is held constant, in order to reduce the mean output voltage.



$$\frac{V_M \searrow}{V_{max}} = \frac{\Delta t}{T \nearrow}$$

5.31 The output voltage is compared to a reference voltage by IC109. The reference voltage at pin 1 is established by the small-value R156/157 relative to the large R155. When IC109 detects less than 5 volts between pins 2 and 1 it switches off, and Q111 is switched on. With Q111 on, diode CR112 is reverse biased and not conducting; current flows through Q111 and L201 to the load, increasing (more negative) linearly by charging the output capacitors C101/102. The capacitors continue charging until the -5V is detected by IC109.

5.32 When IC109 detects more than 5 volts, it switches on and Q111 is switched off. With Q111 off, L201 current starts to decrease and CR112 is forward biased; the current now flows through CR112, and discharging from C101/102, decreases linearly. When the sense voltage falls below the reference, IC109 switches Q111 back on and the cycle repeats.



5.33 Overvoltage Crowbar. An overvoltage detection circuit (crowbar) for the -5V supply is made up of a threshold detector (Q106) and transistor (Q113). If the supply output voltage increases beyond the nominal value, between -6 and -7.5 volts, Q106 switches on and the transistor conducts to short-circuit the supply.

5.34 Overcurrent Detection. The overcurrent circuit comprises sensor R151/R150/PR101, switches Q107 and Q109, thyristor CR115, and switch Q110. An overcurrent through the sensing resistor network produces an increased voltage across the base-emitter of Q107 which switches it on. Transistor Q109 then switches on, and CR115 fires. CR115 switches off Q110 (regardless of the voltage operation through IC109) and holds it off until the current drops back below the maximum of two amps.

5.35 ADJUSTMENTS

The +5V and +16V regulators can each be adjusted for voltage level and overcurrent by trimpots located on circuit card PO. The switching frequency, which is produced by a clock circuit common to these two supplies, is non-adjustable. The -5V regulator can be adjusted, for current protection only, by a trimpot located on circuit card P1.

- +5V output voltage is adjusted by potentiometer PR1.
- +5V overcurrent is adjusted by potentiometer PR2 for a value of 43 amps.
- +16V output voltage is adjusted by potentiometer PR3.
- +16V overcurrent is adjusted by potentiometer PR4 for a value of 9 amps.
- -5V overcurrent is adjusted by potentiometer PR101 for a value of 2 amps.

Power sequence adjustments are made by trimpots located on circuit card P1.

- Power-Off detection time (paragraph 5.39) is adjusted to 10 ms (with mains at 220V) by potentiometer PR103.
- The +16V detector is adjusted by PR102 to switch on when the 16-volt supply reaches 14.7 volts (paragraph 5.37).

5.36 POWER SEQUENCE LOGIC

The power sequencing logic controls the power-on and power-off sequence of the 5-volt and 16-volt supplies and the power logic signals RSLN and PWFN. The logic is included on regulation card P1, and shown on the power supply schematic, Figure 5-3, Sheet 1. A block diagram is shown in Figure 5-4, and Figure 5-5 gives the sequence timing.

5.37 Power-On Sequence. When the power is switched on, the two 5-volt supplies begin to rise; when they reach their nominal value, relay K102 energizes and blocks the INH2 signal (paragraph 5.25). Also at power-on time, the mains detector circuit (amplifier IC103 and schmitt trigger 108-3) generates the VSECTN signal.

5.38 When VSECTN goes low, the INH-1 circuit begins a 300ms delay. During this delay, the INH1 signal blocks turn-on of the +16V regulator (paragraph 5.25). At the end of INH1 time, RVSECT1 is generated while VSECTN and INH1 are both low. Delay 1 is not triggered by the negative-going VSECTN. RVSECT2 drops when RVSECT1 comes on.

5.39 Also at the end of INH1 time, the +16V supply switches on and begins its slow rise. When the 16-volt output reaches 14.7 volts (in about 250 ms), the +16V Detector circuit (amplifier IC106 and schmitt trigger 108-6) generates

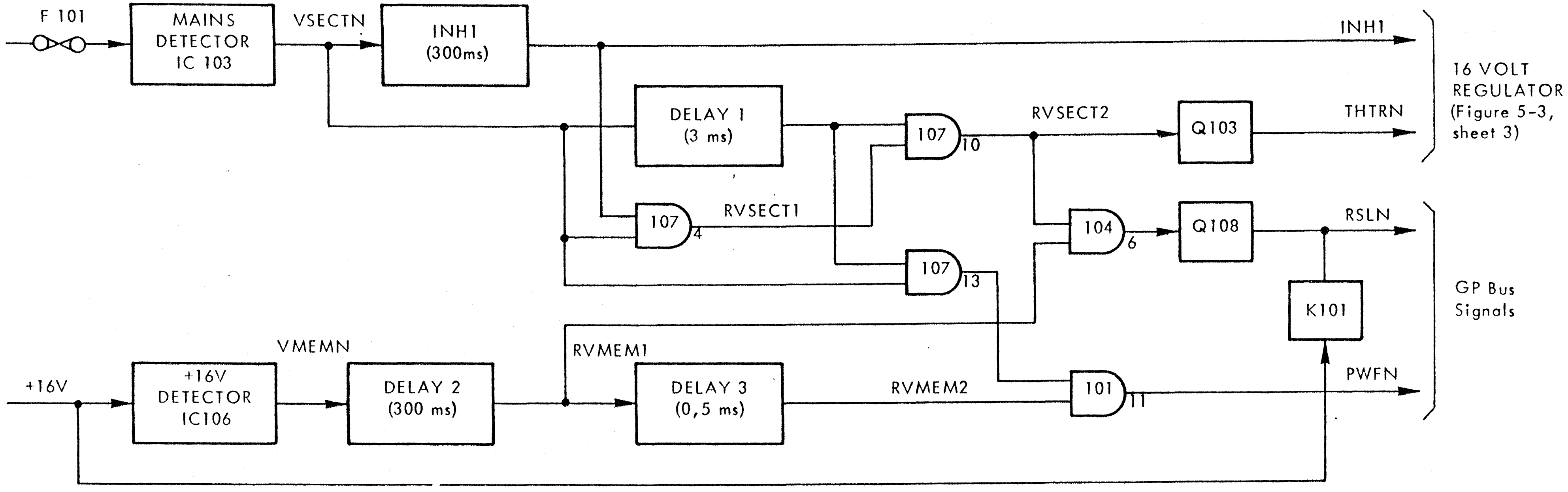


Figure 5-4 Power Sequencing Block Diagram

VMEMN (memory voltage). The leading edge of VMEMN triggers Delay-2. RVMEM1 is generated approximately 300 ms after VMEMN, when Delay-2 drops. RVSECT2 (inverted at gate 101-3) and RVMEM1 together switch off Q108 to terminate the reset-line signal RSLN.

5.40 Delay-3 is an R-C circuit (R128 and C124) which produces the RVMEM2 signal 0.5 ms after the rise of RVMEM1. RVMEM2 terminates the power failure signal PWFN, as long as VSECTN and DELAY1 are both low.

5.41 Power-Off Sequence. The Mains Detector circuit (amplifier IC103 and schmitt trigger 108-3) detects any mains failure longer than 10 ms, and indicates the failure by de-activating the VSECTN signal. The circuit uses the discharge time of C127 through PR103 and R133. The time constant is adjusted by PR103 so that the dropping power reaches the critical level at 10 ms.

5.42 The rising edge of VSECTN drops RVSECT1 without a delay, via the the bypass of the INH-1 circuit. VSECTN immediately generates power-failure signal PWFN via gates 107-12/13, 101-13/11, and 104-9,10/8. The Delay-1 circuit drops 3 ms after RVSECT1 falls, and RVSECT2 goes high. RVSECT2 thus generates reset-line signal RSLN (via gates 101-1,2/3 and 104-4/6) 3 ms after PWFN.

5.43 The RVSECT2 signal switches on transistor Q103 to generate signal THTRN. This signal activates the +16V overvoltage circuit which quickly shuts off the +16V supply. The loss of the +16 volts also drops out relay K101; the closed contacts then ground RSLN, thus holding the signal in its active state while power is off. Since transistor Q108 operates after K101 for power on and before K101 for power off, contact bounce is masked from the reset line.

5.44 The +5V supply begins to drop after the +16V supply is off. The fall time of the +5V supply is about 20 ms with minimum load.

5.45 MECHANICAL

The power-supply chassis is mounted on a base plate in the basic mounting box (Figure 5-6). The power supply output voltages are connected to the system circuit cards via back-panel connector 3. The main power-supply assemblies are shown in Figure 5-7. Most of the electronic circuits are located on two printed-circuit cards, P0 and P1 (Figure 5-8). Power transistors and rectifiers and the fuses are mounted on the heat-sink assembly (Figure 5-9). A few very large components (coils and capacitors) are mounted directly on the chassis base plate. The mains power transformer (T201) and the two fans are mounted on the basic box at the rear. The key switch is mounted on the front of the basic box (Figures 5-6, 5-9). All components not mounted on the two circuit cards have the reference designations 2__.

5.46 Top Cover Removal

Figures 5-6 and 5-7 show the power supply with the top cover removed. The cover is attached by five screws : two on each side and one in the back, at the corner near the fan.

5.47 Power-Supply Chassis Removal

The power -supply chassis (except mains transformer and fans) can be removed on its base plate from the basic mounting box. (Refer to Figure 5-7.)

Disconnect :

- connections at connector 3 (five small plugs, not the two bigger ones; main ground, at connector-3 end).
- RTC connector.
- TR201 outputs 10 through 21.
- Circuit card P0, for access to remote-key connections :
  a. connector plug off.
  b. Remove four screws and spacers onto P1 (one at each corner of P0). A ground wire from the remote key is attached by one of the corner screws.

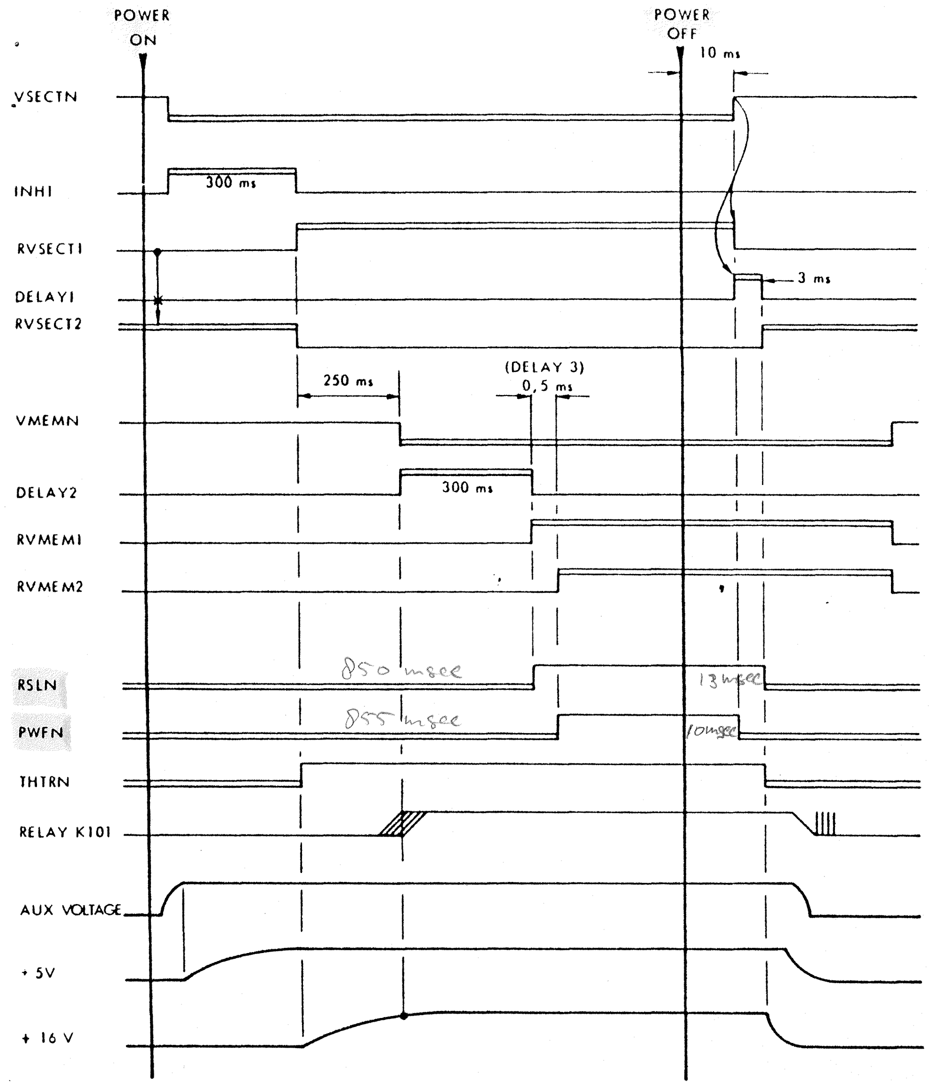
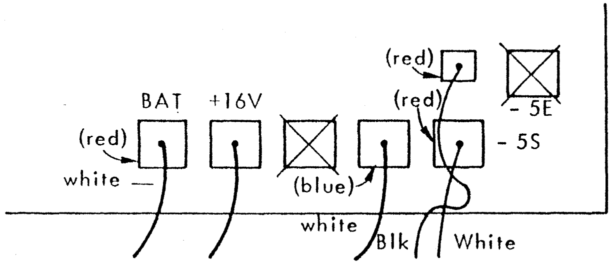


Figure 5-5 Power Sequence Timing

- remote-key connections A, B, C.
- P1 power connections (five plugs) as follows :



- Six screws, three on each side, directly through base plate -- not those through any other brackets mounted on the base plate (however, one does hold a plastic cable clamp).

5.48 Heat-Sink Assembly Removal

The heat-sink assembly can be removed from the basic mounting box. The * indicates the steps already done if the power-supply chassis has been removed from the mounting box. (Refer to Figure 5-7). Disconnect:

- * connections at connector 3 (five small plugs, not the two bigger ones; main ground, at heat-sink end).
- connector plugs at P0 and P1.
- * RTC connector.
- * TR201 outputs 10 through 21.
- three cables to C204 and C205 (the two biggest capacitors).
- Unsolder three wires to C206 and C207 (the two smaller capacitors).
- +5V cable to L203.
- +5V power cable (through L204) at both ends.
- ground connection between heat sink and base plate.
- four mounting screws, each through a plastic foot bracket, from the base plate.

5.49 Circuit-Card P0 Removal

The P0 circuit card must be removed before the power-supply chassis is removed or the P1 circuit card is removed. P0 can also be removed alone from the basic mounting box. (Refer to Figure 5-7). Disconnect:

- connector plug.
- four screws and spacers onto P1 (one at each corner of P0). A ground wire from the remote key is attached by one of the corner screws.

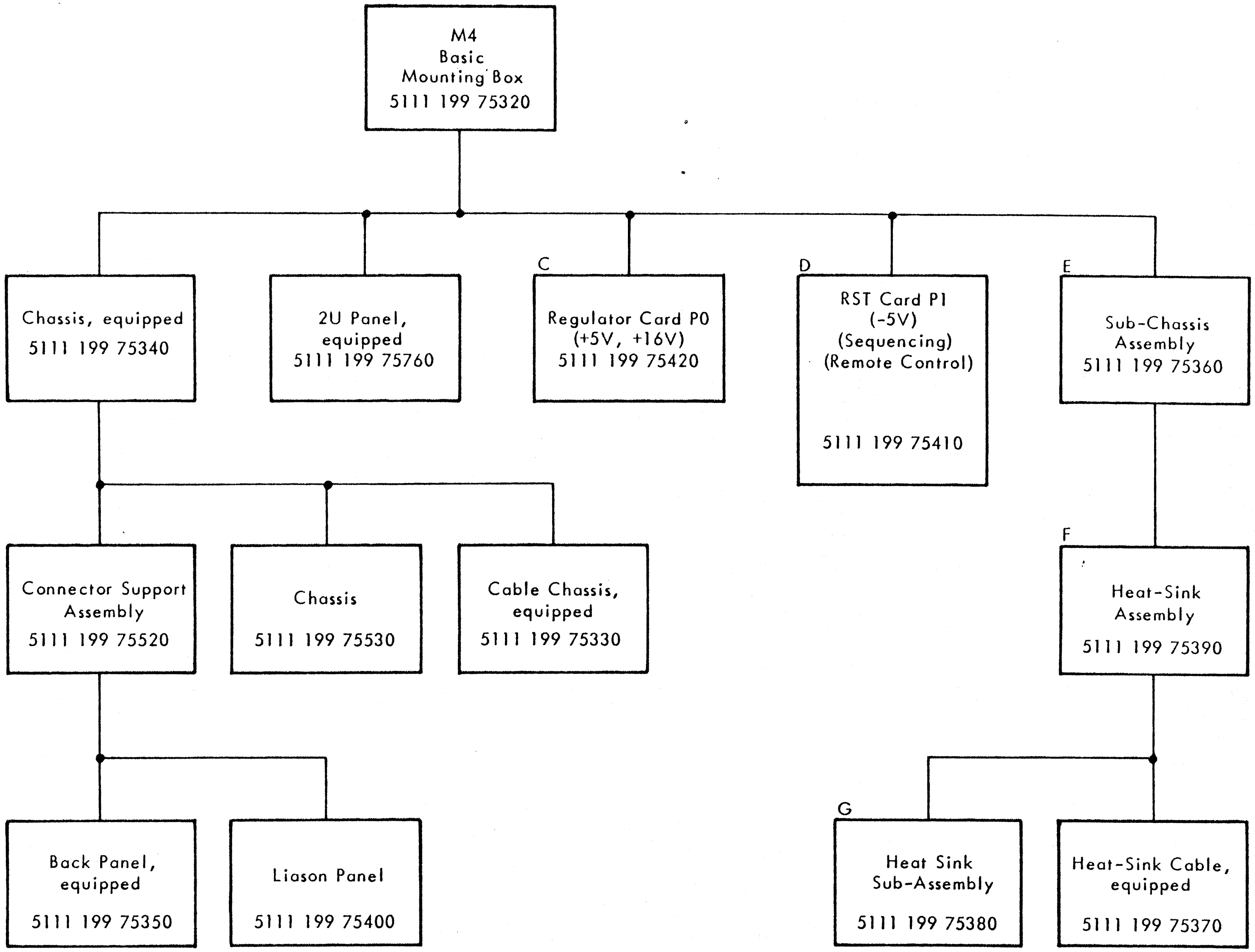
5.50 Circuit-Card P1 Removal

The P1 circuit card can be removed from the power-supply chassis. The * indicates the steps already done if the chassis has been removed from the mounting box. (Refer to Figure 5-7). Disconnect:

- * and remove card P0 (previous paragraph).
- * remote-key connections A, B, C.
- all eight power connections at connector 3.
- the +5V cables to L203 and L204 (from the same point on the circuit card).
- ground cable to the heat sink.

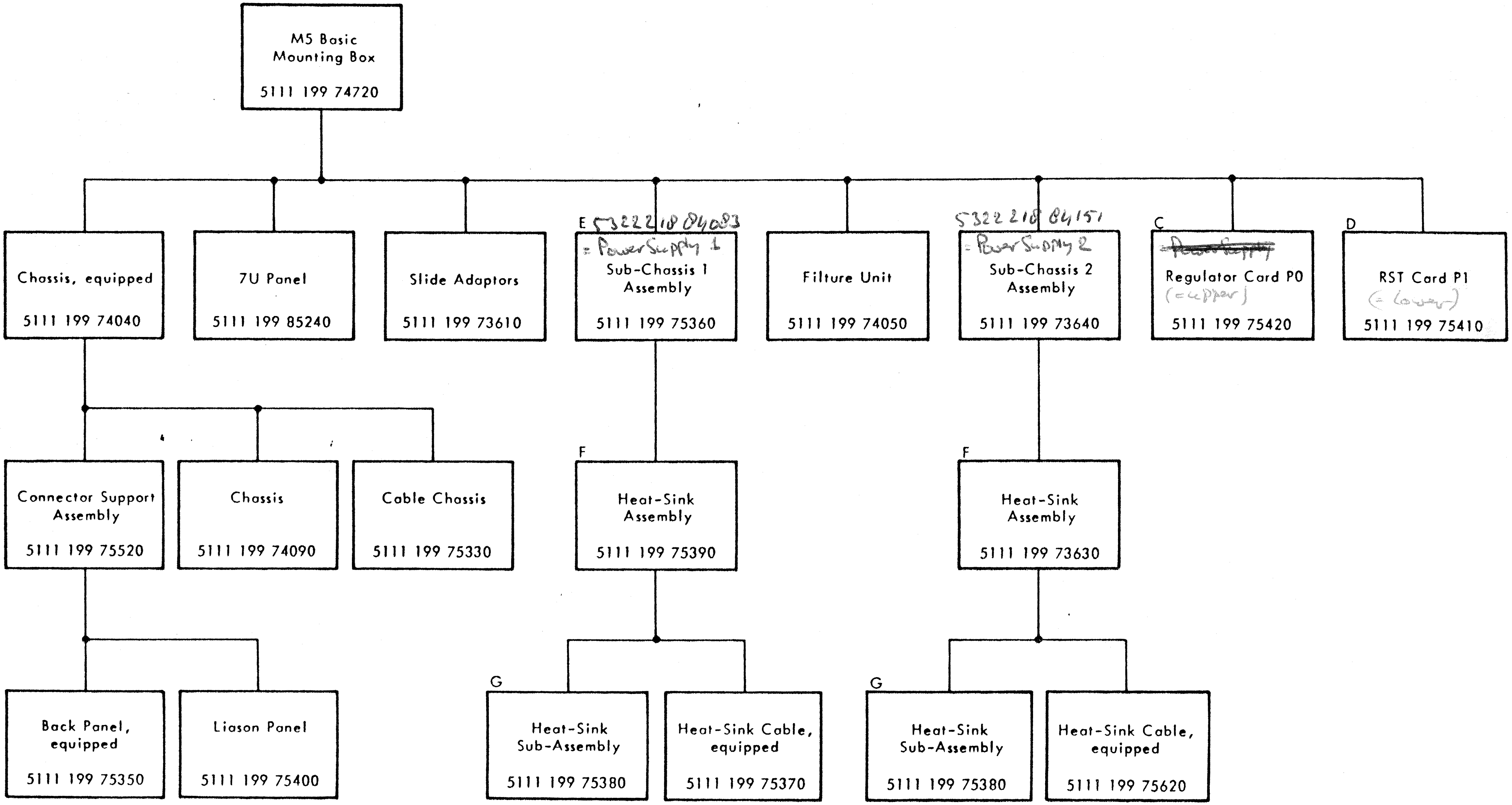
5.51 List of Components

All power-supply components are listed in the following parts-list, Table 5-1.



C to G = Parts Lists Included

Table 5-1A M4 Parts List Guide



C to G = Parts Lists Included

Table 5-1B M5 Parts List Guide

Table 5-1C Regulator Card PO Parts List

Reference	Description	12NC Code
	Printed Circuit	5111 100 05843
IC1,2,3,9.	Integrated Circuit NE 555 V.	
IC7.	Integrated Circuit μA 710 DC.	
IC4,6,8.	Integrated Circuit UGA 7723 393.	
IC5.	Voltage Regulator 7815 (TO220).	
Q 12.	Transistor 2N 3055 (TO3)	
Q2,4.	Transistor BDX 77 (TO220)	
Q 1,3,7,8,11,17,20.	Transistor 2N2219	
Q 9,14,15.	Transistor 2N2905	
Q 13.	Transistor BDX78 (TO220)	
Q 5,6,10,16,18,19,21,22.	Transistor BSX20	
CR4.	Diode BZX79 C4 V7.	
CR8,10,14,15.	Diode BZX79 C10.	
CR9.	Diode BZX79 C16.	
CR7.	Diode BZX79 C12.	
CR2,3,11,12.	Diode BZX75 C3 V6.	
CR5,16.	Diode BAX 12.	
CR1.	Diode BYX49-300.	
CR6.	Diode BZX79 C5 V6.	
CR13.	Thyristor 2N2323.	
P2,3.	Potentiometer 2600 P102.	
P4.	Potentiometer 2600 P203.	
P1.	Potentiometer 2600 P502.	
R11,38,39,47.	Resistor 1KΩ, 0.25W, 1%.	
R3.	Resistor 5.62KΩ, 0.25W, 1%.	
R13.	Resistor 215Ω, 0.25W, 1%.	
R49.	Resistor 68KΩ, 0.25W, 5%.	
R46.	Resistor 10KΩ, 0.25W, 1%.	
R4,8,12, ,21,24,25,26,29,30,32,33, 36,50,51,52,56.	Resistor 1KΩ, 0.25W, 5%.	
R15.	Resistor 200Ω, 0.25W, 5%.	
R14.	Resistor 1.2KΩ, 0.25W, 5%.	
R16,31,48,54,58.	Resistor 2KΩ, 0.25W, 5%.	
R9.	Resistor 5.1KΩ, 0.25W, 5%.	
R10.	Resistor 510Ω, 0,25W, 5%.	
R60,62.	Resistor 100Ω, 0,25W, 5%.	
R57.	Resistor 4.7KΩ, 0,25W, 5%.	
R40.	Resistor 8.2KΩ, 0,25W, 5%.	
R59,61.	Resistor 390Ω, 0,25W, 5%.	
R20.	Resistor 470Ω, 0,25W, 5%.	

Table 5-1C Contd.

Reference	Description	12NC Code
R22,27,28.	Resistor 10KΩ, 0.25W, 5%.	
R18.	Resistor 150Ω, 0.25W, 5%.	
R17,23.	Resistor 1.5KΩ, 0.25W, 5%.	
R35,37,44,45.	Resistor 3.83KΩ, 0.5W, 1%.	
R1.	Resistor 200Ω, 0.5W, 5%.	
R34.	Resistor 20Ω, 0.5W, 5%.	
R53.	Resistor 3KΩ, 0.5W, 5%.	
R2.	Resistor 47Ω, 10%, WRO617E.	
R41,42,43.	Resistor 1.5KΩ, 5%, WRO617E.	
R5,6,7.	Resistor 33Ω, 5%, WRO825E.	
R63.	Resistor 620Ω, 0.25W, 5%.	
R64.	Resistor 3KΩ, 0.25W, ± 5%.	
R55.	Resistor 1.47K, 0.25W, 1%.	
R65.	Resistor 1.21K 0.125W ± 1%.	
R66.	Resistor 10KΩ, 0.25W, ± 1%.	
R19	Resistor 680Ω 0.25W ± 5%	
C4,8.	Capacitor 0,01μF, 125V, 1%.	
C3.	Capacitor 1500μF, 10V.	
C2,6,9,11,20,25,26,28,31,39.	Capacitor 10nF, ceramic	
C19.	Capacitor 100pF, ceramic	
C5,13,16,30.	Capacitor 0,1μF, 100V, 10%, MPR	
C1,10.	Capacitor 0,01μF, 250V, 10%, MPR	
C7,17,18,24,27.	Capacitor 15μF, 20V, CTS13.	
C12,15,C22.	Capacitor 33μF, 10V, CTS13.	
C23.	Capacitor 3.3μF, 16V, CTS13.	
C14.	Capacitor 220μF, 25V, FITCO.	
C33.	Capacitor 100μF, 10V, FITCO.	
C32,34.	Capacitor 0.022μF, 250V, MPR	
C37.	Capacitor 470pF, 10%, ceramic	
C29.	Capacitor 0,47μF, 100V, 10%, MPR.	
C38.	Capacitor 10,000pF, 100V, ± 10%, ceramic	
C35.	Capacitor 10μF, 25V, FITCO.	
	Heat Sink PB1-2U.	
	Mica insulator 56325.	
T 1.	Transformer TRI M4.	

Table 5-1D RST Card P1 Parts List

Reference	Description	12NC Code
	Printed Circuit	5111 100 05854
IC103,106.	Integrated Circuit UGA 7723 393.	
IC101,108.	Integrated Circuit 74132.	
IC102,105.	Integrated Circuit 9602.	
IC107.	Integrated Circuit 7402.	
IC104.	Integrated Circuit 1801.	
IC109.	Regulator 7905 (TO220).	
Q 111,113.	Transistor BDX77 (TO220).	
Q 103,112.	Transistor 2N2219.	
Q 109.	Transistor 2N2905.	
Q 104,107.	Transistor BSX20.	
Q 105,108,110,114.	Transistor BSX60.	
Q 101,102,106.	Transistor 2N2906.	
CR 107,116.	Diode BZX79 C4 V7.	
CR 102,109.	Diode BZX79 C5 V6.	
CR 106.	Diode BZX79 C18 or C20	(later version)
CR 114.	Diode IN4005.	
CR 104,105,110,111,118, 121.	Diode BAX12.	
CR 112.	Diode MR820.	
CR 101,103.	Thyristor BTW92/600RM.	
CR 117.	Thyristor 2N2323.	
CR 113.	Triac TXAL 615 M.	
CR 119	Diode BYZ 14-50	(later version)
CR 120	Diode BZX 75 C2V1	(later version)
P 101,103.	Potentiometer 2600 P 102.	
P 102.	Potentiometer 2600 P 502.	
R 105,127.	Resistor 46.4Ω, 0.25W, 1%.	
R 113.	Resistor 121Ω, 0.25W, 1%.	
R 134.	Resistor 19.6KΩ, 0.25W, 1%.	
R 117.	Resistor 5.11KΩ, 0.25W, 1%.	
R 118,119.	Resistor 4.22KΩ, 0.25W, 1%.	
R 130.	Resistor 31.6KΩ, 0.25W, 1%.	
R 115,116,135,137,143,144,167.	Resistor 1 KΩ, 0.25W, 5%.	
R 123.	Resistor 270Ω, 0.25W, 5%.	
R 133,150	Resistor 510Ω, 0.25W, 5%.	
R 103,111,112,126,128,131,142,153, 154,160,161,166.	Resistor 100Ω, 0.25W, 5%.	
R 124.	Resistor 300Ω, 0.25W, 5%.	
R 158.	Resistor 51Ω, 0.25W, 5%.	
R 132,141.	Resistor 330Ω, 0.25W, 5%.	
R 136,146.	Resistor 30KΩ, 0.25W, 5%.	

Table 5-1D Contd.

Reference	Description	12NC Code
R 159.	Resistor 470Ω, 0.25W, 5%.	
R 156,157.	Resistor 1Ω, 0.25W, 5%.	
R 122.	Resistor 680Ω, 0.25W, 5%.	
R 125.	Resistor 33Ω, 0.25W, 5%.	
R 145.	Resistor 120Ω, 0.25W, 5%.	
R 138,147.	Resistor 2.4KΩ, 0.25W, 5%.	
R 101,106.	Resistor 100Ω, 0.5W, 5%.	
R 104,152,192.	Resistor 10Ω, 0.5W, 5%.	
R 149.	Resistor 1KΩ, 0.5W, 5%.	
R 114.	Resistor 200Ω, 0.5W, 5%.	
R 102,107.	Resistor 300Ω, 0.5W, 5%.	
R 120.	Resistor 510Ω, 0.5W, 5%.	
R 121.	Resistor 240Ω, 0.5W, 5%.	
R 108,109,110.	Resistor WRO617E 560	
R 151,168.	Resistor 0.3Ω, 5%, 224E.	
R 139.	Resistor 10KΩ, 0.25W, 5%.	
R 164.	Resistor 2KΩ, 0.25W, ± 5%.	
R 165.	Resistor 390Ω, 0.125W, 5%.	
R 162.	Resistor 6.8KΩ, 0.25W, 5%.	
R 140.	Resistor 200Ω, 0.25W, 5%.	
R 163.	Resistor 20KΩ, 0.25W, 5%.	
R 155.	Adjustable Resistor 510Ω to 2 KΩ, 0.5W, 5%, E 24.	
R 169.	Resistor 2.7KΩ, 0.25W, 5%	(later version)
R 129	Resistor 5.1KΩ	
C 123,126,128,130,134,136,138,141, 144,190.	Capacitor 10nF, ceramic	
C 131,139.	Capacitor 560pF, ceramic	
C 142,143.	Capacitor 1000pF, ceramic	
C 129.	Capacitor 56pF, ceramic	
C 115,116,120,122, 119.	Capacitor 0.1µF, 100V, 10%, MPR	(later version)
C 119,132.	Capacitor 0.01µF, 250V, 10%, MPR	
C 135.	Capacitor 0.47µF, 100V, 10%, MPR	
C 117,125,137.	Capacitor 33µF, 10V, CTS13	
C 124,127,140.	Capacitor 3.3µF, 16V, CTS13	
C 118,121,133,145,149.	Capacitor 22µF, 25V, FITCO	
C 146.	Capacitor 47000pF, 400V, 20%, PMA	
C 147.	Capacitor 22000pF, 400V, 20%, PMA	
C 148.	Capacitor 0.1µF, 630V, 20%, PMA	
C 104.	Capacitor 680µF, 25V.	
C 105-114.	Capacitor 1500µF, 10V.	
C 101,102.	Capacitor 100µF, 10V, FITCO	
C 150	Capacitor 22 µF 10V.	(later version)

Table 5-1D Contd.

Reference	Description	12NC Code
K 101.	Relay MRMD 15006.	
K 102.	Relay MRMD 15005.	
F 101.	Fuse D1/0.1.	
	Mica insulator 56325	
	Triac Heat-Sink	5111 100 22541.

Table 5-1F Heat Sink Assembly Parts List

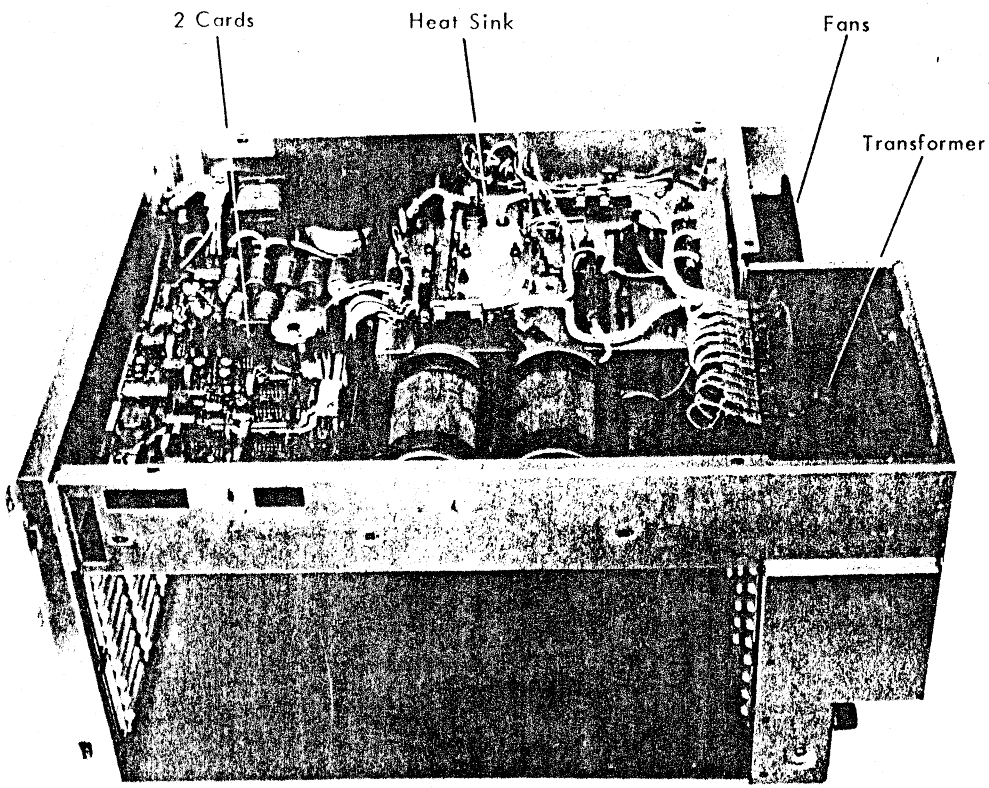
Reference	Description	12NC Code
	Heat-Sink Sub-Assembly	5111 199 75380
	Harness (M4, M5) or	5111 199 75370
	Harness (M5).	5111 199 73630
R203, 204, 205.	Resistor 10Ω, 0.5W, 5%.	
R206.	Resistor 27Ω, 0.5W, 5%.	
C201, 202, 203.	Capacitor 0.022µF, 250V, 10%, PMA.	
C210, 211.	Capacitor 10 µF, 100V, 20%, PMA.	
C212	Capacitor 3,3 µF 25V	Late Version
F201.	Fuse A13/20.	
F202.	Fuse D8/10.	
F203.	Fuse D1/2.	
F204, 205.	Fuse D1/3.15.	
REG 1	Regulator 7805 (TO22)	(later version)

Table 5-1E Sub-Chassis Assembly Parts List

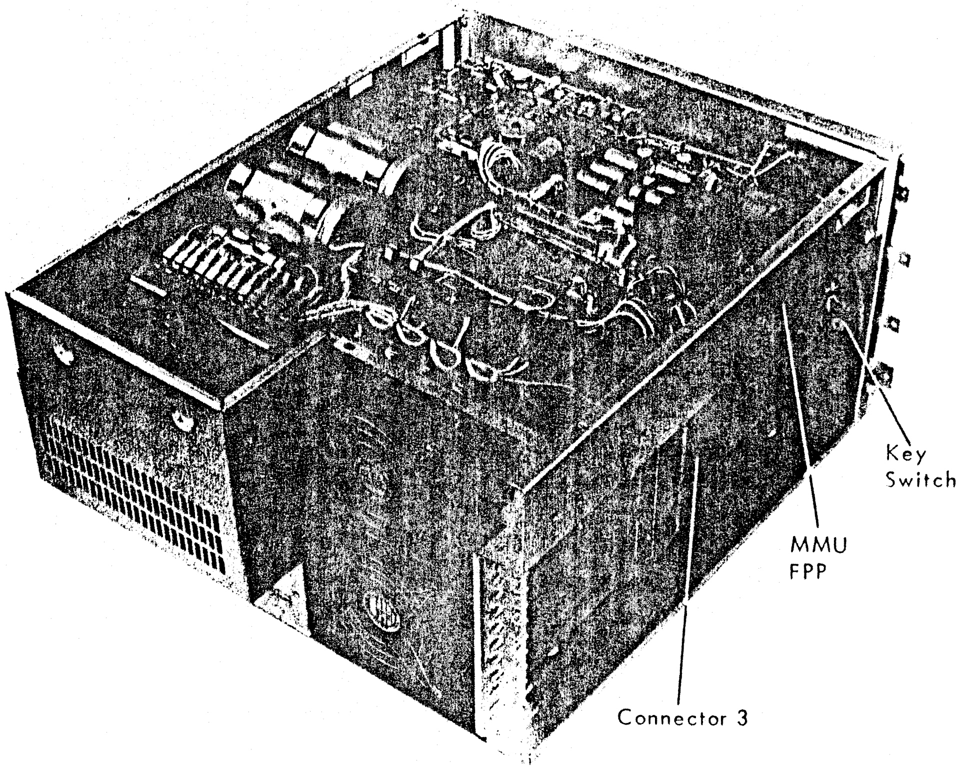
Reference	Description	12NC Code
	Sub-Chassis	5111 100 22312
	Heat-Sink Assembly	5111 199 75390
L201.	Inductance SLF 2091	
L202.	Inductance SLF 1712	
L203.	Inductance SLF 2101	
C204-C205.	Capacitor 33000µF, 40V.	
C206-C207.	Capacitor 5000+5000µF, 40V.	
R 208-209.	Resistor 1KΩ, WR0617E.	
R210-211.	Resistor 3.9KΩ, 0.5W, 5%.	
R202.	Resistor 560Ω, 0.5W, 5%.	
R212.	Resistor 30Ω, 25 W, ± 3%.	
R213.	Adjustable Resistor 22Ω to 3KΩ, 0.5W, ± 5%. or 300Ω - 910Ω	(later version)

Table 5-1G Heat-Sink Sub-Assembly Parts List

Reference	Description	12NC Code
	Heat Sink	5111 100 22523
L204.	Inductance SLF 2541.	
IC 201.	Regulator 7815 (T03).	
Q 201, 202, 203, 204.	Transistor 2N5685.	
CR201, 202.	Diode RPR 1040 R.	
CR203.	Diode 1N3910 R.	
CR204.	Diode BZY93 C9V1.	
CR205, 206, 207, 208.	Diode BYX52 300R.	
U 201.	Bridge MDA 952-2.	
R 207.	Resistor 0.1 Ω, 3%, (RH10).	
	Relay REVIC 1D.	



TOP/CARD SIDE



REAR/BACK-PANEL SIDE

Figure 5-6 Basic Mounting Box

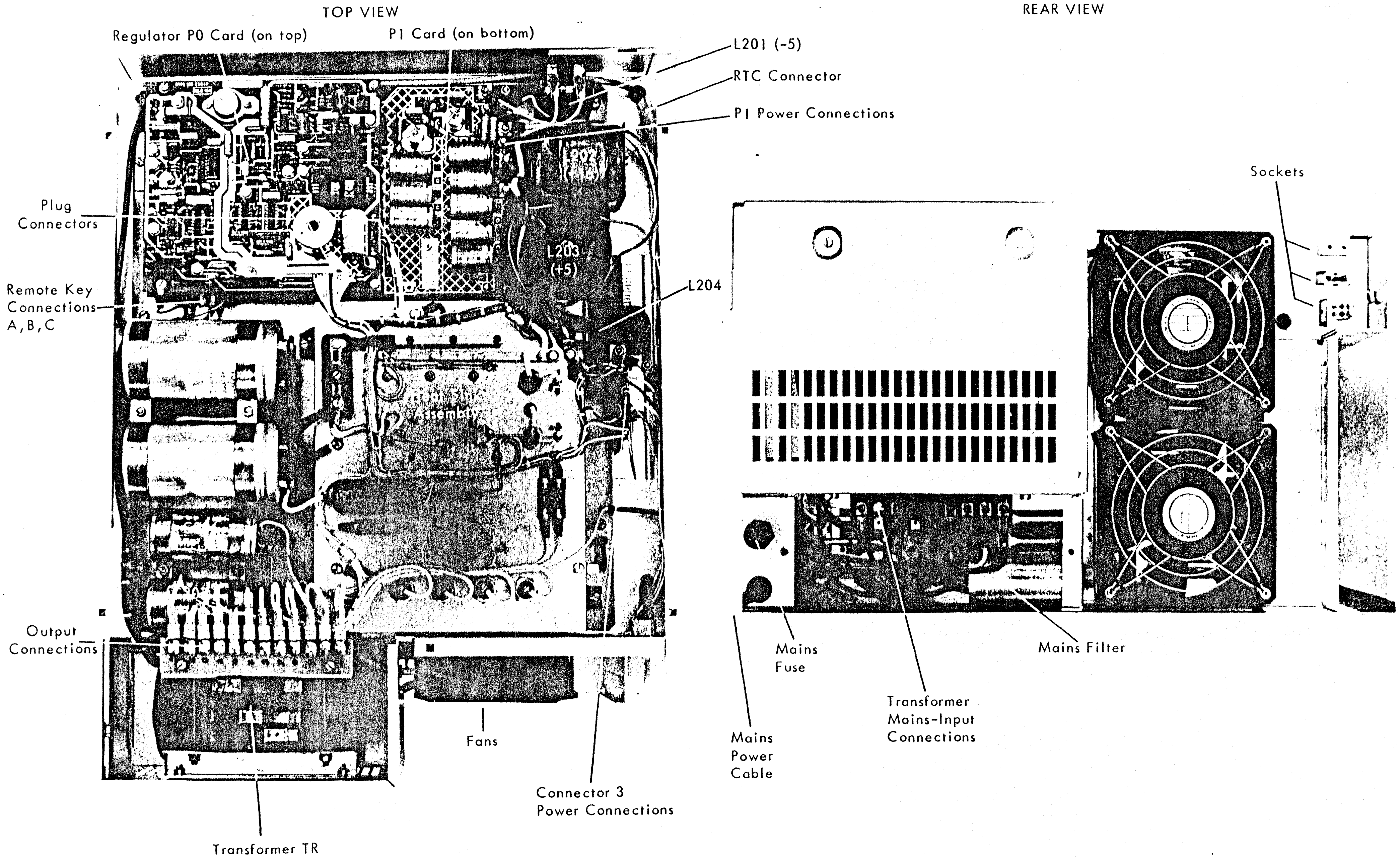
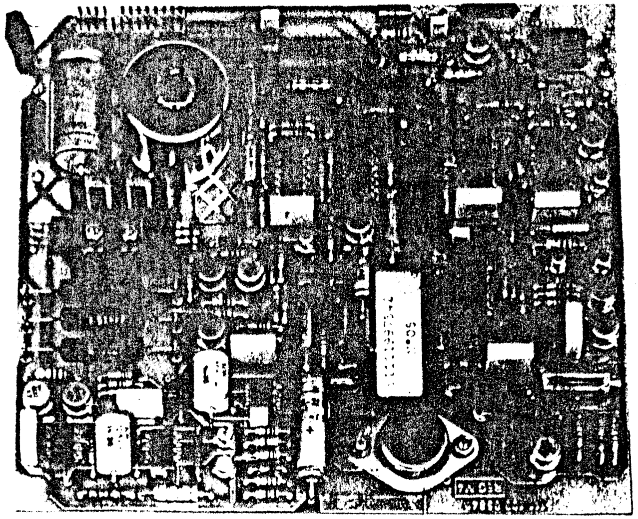
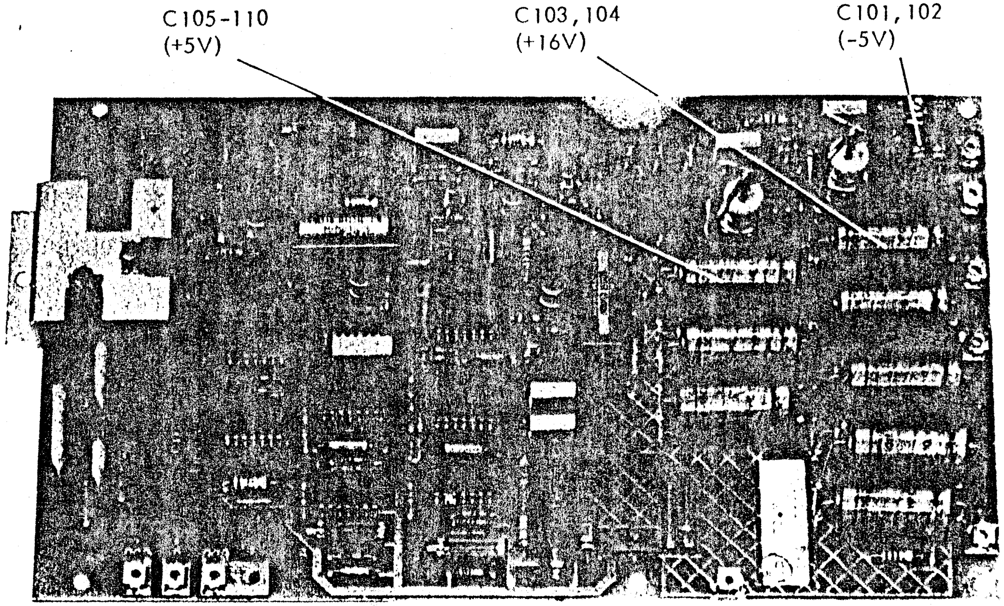


Figure 5-7 Power Supply Assembly Locations

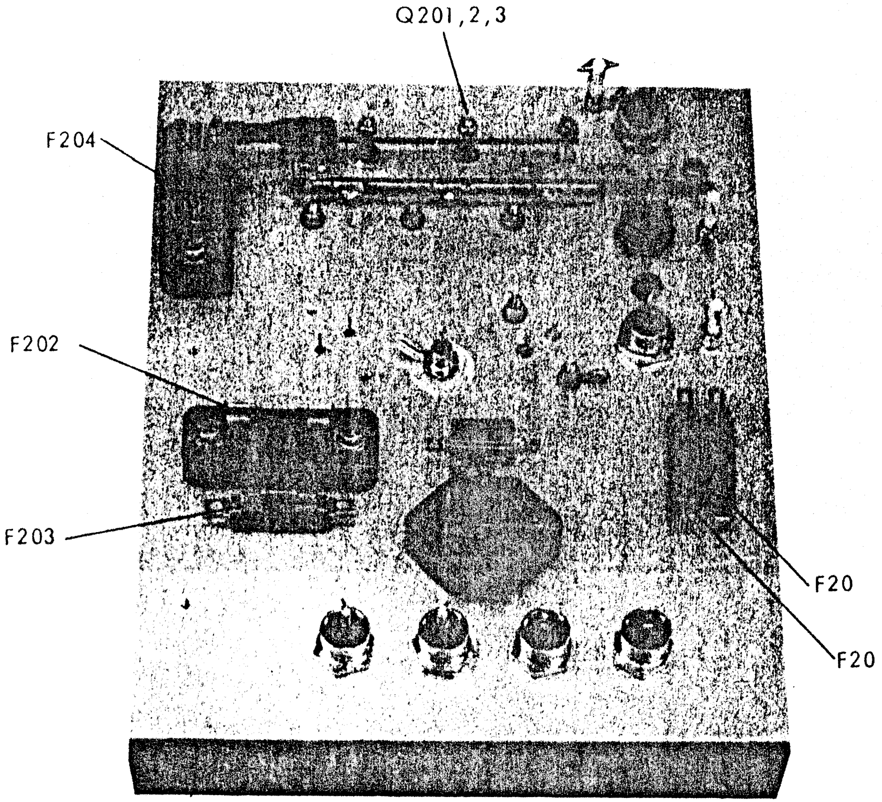


REG CARD Pφ



RST CARD P1

Figure 5-8 Power Supply Circuit Cards



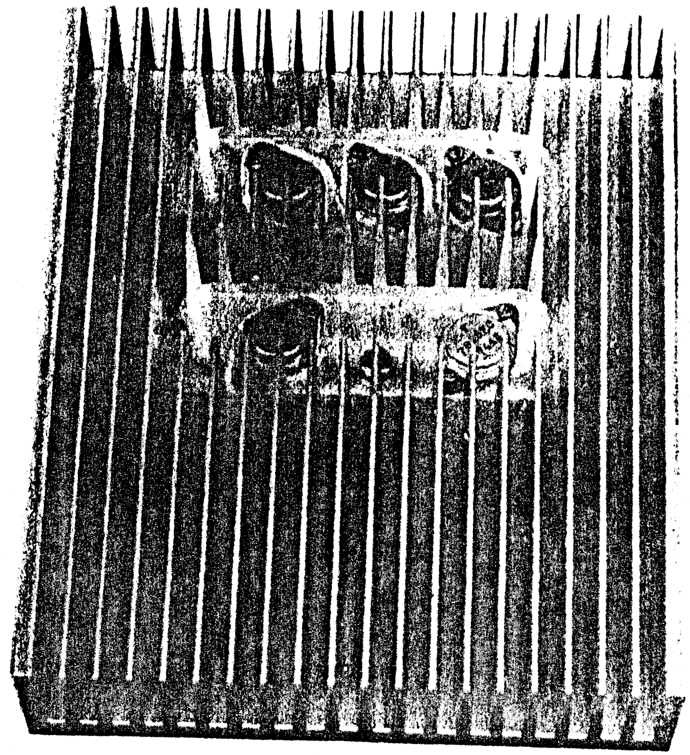


Figure 5-9 Heat-Sink Assembly

5.52 POWER SUPPLY FOR EXTENSION RACK E2

The power supply provides a +5V 2.4% regulated d.c. voltage, +18V and -18V unregulated d.c. voltages, and the Power Failure and Reset Logic signals for the control units in the rack. It also provides the +19V used by the mains detector logic. The power supply is made up of five sub-assemblies. These are:

- Mains Filter and Local/Remote switching
- Mains Transformer
- Power Block
- Sequence Card
- Fan unit to cool the whole cabinet

The mechanical layout of these sub-assemblies is shown in Figure 5-10.

5.53 ELECTRICAL DESCRIPTION

Figure 5-11 shows a block diagram of the Power Supply and Figure 5-15 is the schematic diagram. The following paragraphs describe the function of each block and relate the blocks to the components on the schematic diagram.

5.54 a.c. Input

The a.c. mains is connected to the mains transformer via a mains filter and a Local/Remote switch S201. The value of the input fuse F303 is for 110/115 volts operation type D8TD/6.3A slow blow and for 220/240 volts operation is type D8TD/3.5A slow blow. With the Local/Remote switch in the Local position the live line of the mains is connected to pin 1 of the transformer via the contact of switch S201. With the Local/Remote switch in the Remote position the live line of the mains is connected via the contact of relay K201, which has to be energised by an external +5V supply.

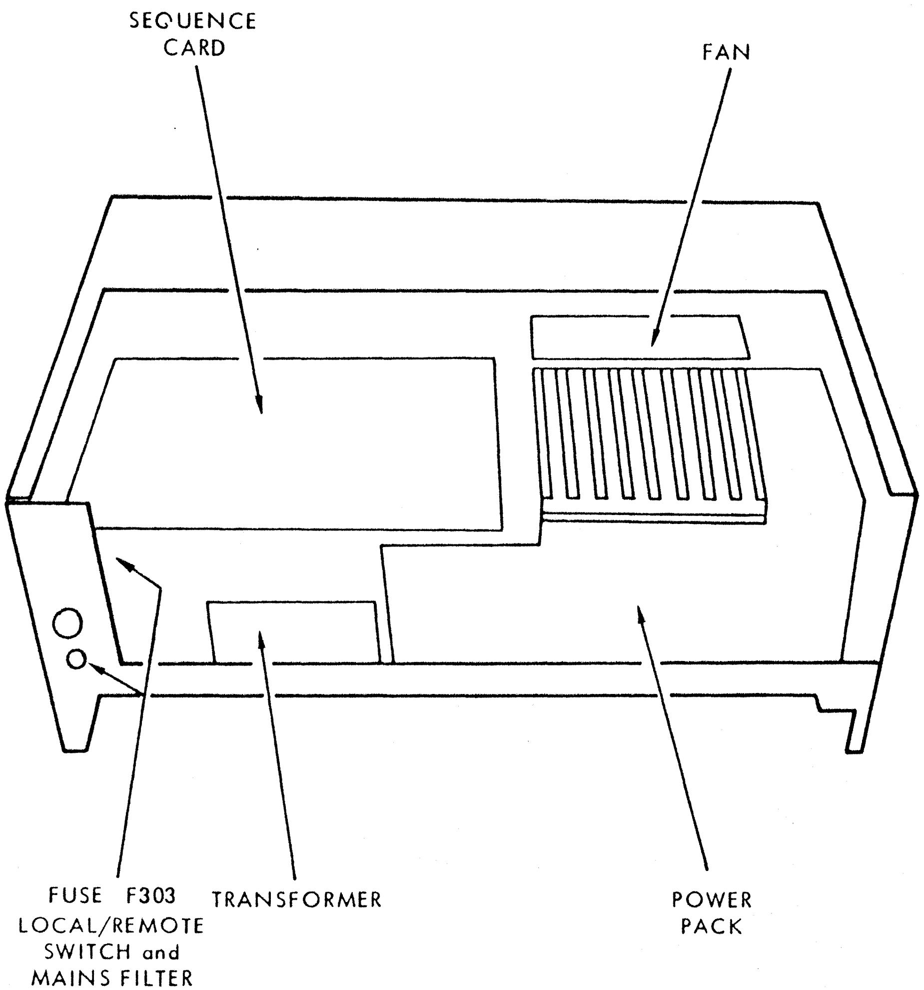


Figure 5-10 Power Supply Sub Assemblies

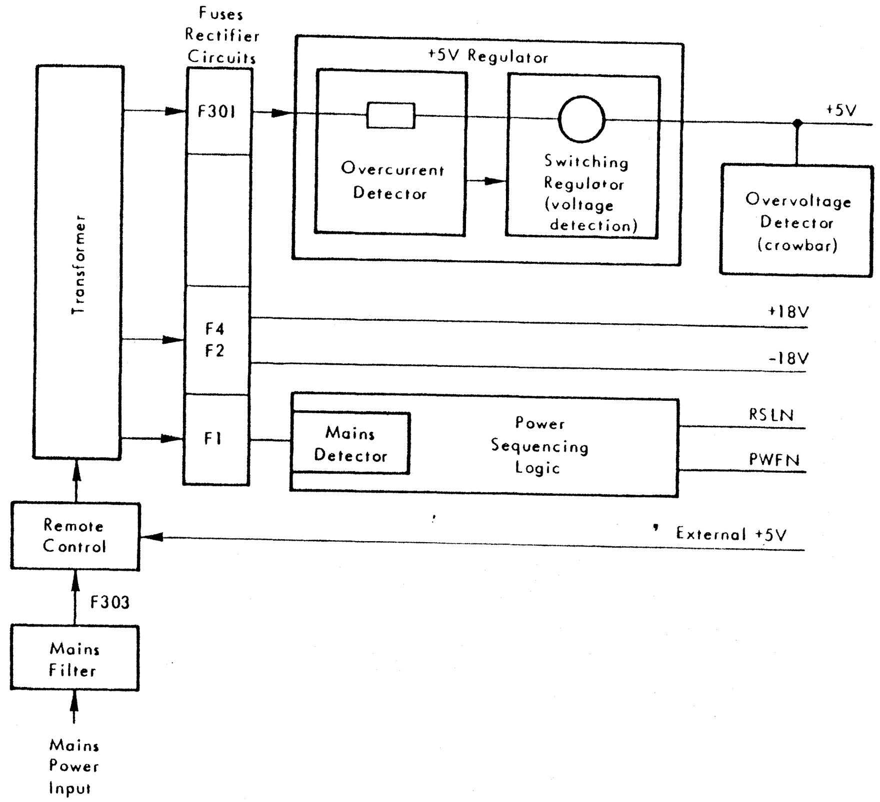


Figure 5-11 Block Diagram

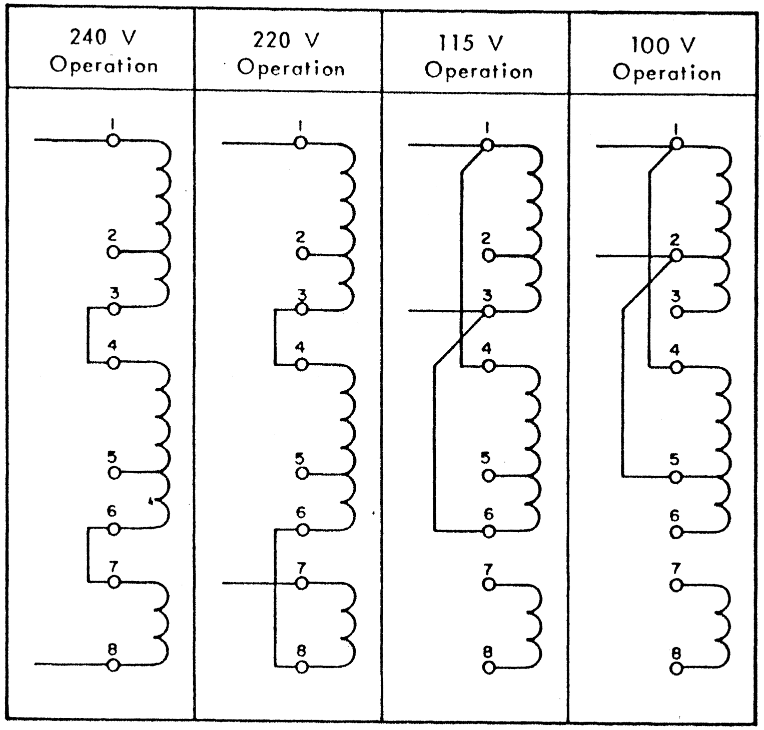


Figure 5-12 Mains Transformer Connections

5.55 Mains Transformer Connections

The mains transformer can be connected to either 240V, 220V, 115V, or 100V mains supply; Figure 5-12shows the different configurations. Pin 9 of the transformer is the shield and is always connected to ground, and the fan is always connected between pins 1 and 3 (115V nominal).

5.56 Rectifiers and Filters

The output voltages from the three secondary windings of the transformer are rectified and filtered to provide four raw d.c. voltages. Fuses F301,F1,F2 and F4 protect the rectifiers and transformer if overload conditions occur.

5.57 +5V Regulator. The raw d.c. voltage for this circuit is provided by a full wave bridge using CR304-CR307 and is filtered by C302; the output at fuse F301 is approximately 30V d.c.

5.58 +18V and -18V Unregulated Voltages. These two voltages are provided by two center tap full wave rectifier circuits CR10-CR13 and are filtered C304 and C305.

5.59 Mains Detector Voltage. This is provided by a center tap full wave rectifier circuit CR8 and CR9 and is filtered by C5; the output voltage is approximately +19V d.c.

5.60 +5V Regulator Circuit

This is a switching regulator using Q301 and Q302 for the switching controlled by IC7. The switching frequency is 20KHz at full load but the frequency will decrease when the load decreases. The frequency is adjusted by changing the value of R49, and the output voltage is adjusted by potentiometer PR1.

5.61 +5V Overcurrent Protection

The overcurrent detector circuit uses transistors Q11 and Q12 and thyristor CR15. Q11 monitors the current flowing through R301 and when the signal is about 700mV Q11 is switched ON and the thyristor is triggered. Then Q12 is saturated so Q301 and Q302 are cut off and the signal from R65 inhibits IC7. Overcurrent adjustment is by potentiometer PR2 and it is normally set for a value of 20.7A at 25°C ambient temperature. Thermistor R68 is included in the adjustment network to give temperature correction.

5.62 +5V Overvoltage Protection

The overvoltage protection is provided by transistor Q101, zener diode CR105, and thyristor CR101. The transistor and zener are the threshold detector and Q101 is normally OFF. When the voltage increases above the operating value of the zener (in this case between 6V and 7V), Q101 is turned ON and the thyristor is triggered short circuiting the output from the +5V supply.

5.63 Sequence Logic

This logic uses the output from the mains detector circuit to control the Switch ON / Switch OFF sequence logic and to provide the Powerfail (PWF) and Reset (RSL) logic signals.

5.64 Mains Detector. The output from the two diodes CR8 and CR9 drives the transistor Q2 circuit that triggers the two monostable chips IC1 and IC4 if a mains failure longer than 10mS occurs. The 10mS delay time is adjusted by changing the value of R4.

5.65 Switching ON. When the mains present signal (from the mains detector circuit) is high on pin 4 of IC4 the monostable is triggered and after a delay of 300mS (to allow the output voltages to reach their normal operating values) the output from pin 7 triggers the other two monostables that enable the PWF and RSL signals. During this delay the output from pin 6 has triggered IC1 and after a delay of 150mS the output from pin 10 activates the transistors of the relay driver (Q3-Q5), and the relay operates opening the contact and removing the ground connection to the collector of Q6; the state of the RSL signal will still stay at the low level (0) until enabled high by the output from IC4 pin 9. When pin 7 of IC4 goes high the signal from pin 3 of IC3 triggers IC1 pin 4 and it is also used to bypass IC4 (which is only used during Switch OFF) and enable RSL to go high.

After a delay of 400µS the output from pin 7 of IC1 goes high enabling the PWF signal to go high and the supplies are considered operational.

5.66 Switching OFF. When either a mains failure longer than 10mS occurs, or the +5V d.c. disappears, or the power supply is switched OFF the following sequence occurs. The mains present signal goes low and bypasses IC4 pin 4 and IC1 pin 4 to send the PFW signal low. At the same time it is used to activate pin 11 of IC4 which triggers and after a delay of 2mS the output from pin 9 sends the RSL signal low. A feedback signal from the RSL logic (via IC6 pin 12) is sent to the relay driver circuit and the relay is de-energised, the contact closes and the RSL line is grounded.

5.67 Timing

The timing diagram of the sequence logic is shown in Figure 5-13 (the circled numbers refer to points on the schematic diagram), and the timing diagram for the d.c. voltages and the logic signals is shown in Figure 5-14.

5.68 Timing Adjustments

The timing of the sequence logic can be adjusted by changing the values of R and C as follows:

- 300mS — change R24 and C11
- 150mS — change R21 and C13
- 400µS — change R19 and C8
- 2mS — change R28 and C10

5.69 MECHANICAL DETAILS

The position of the extention cabinet (E2) in the 19in rack in relation to the other units will decide if the cabinet has to be withdrawn completely before trying to troubleshoot the power supply. The following description assumes that the cabinet has to be removed from the rack, so if this does not apply to your system the instructions for removal and replacement can be ignored.

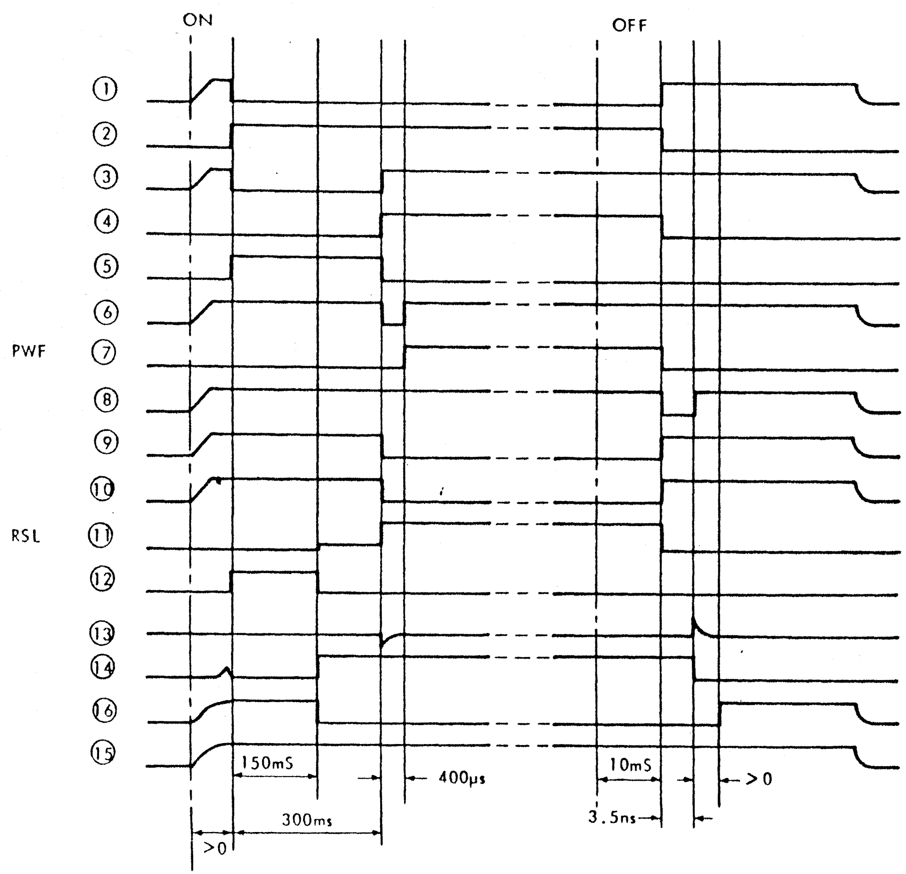


Figure 5-13 Timing Diagram of Sequence Logic

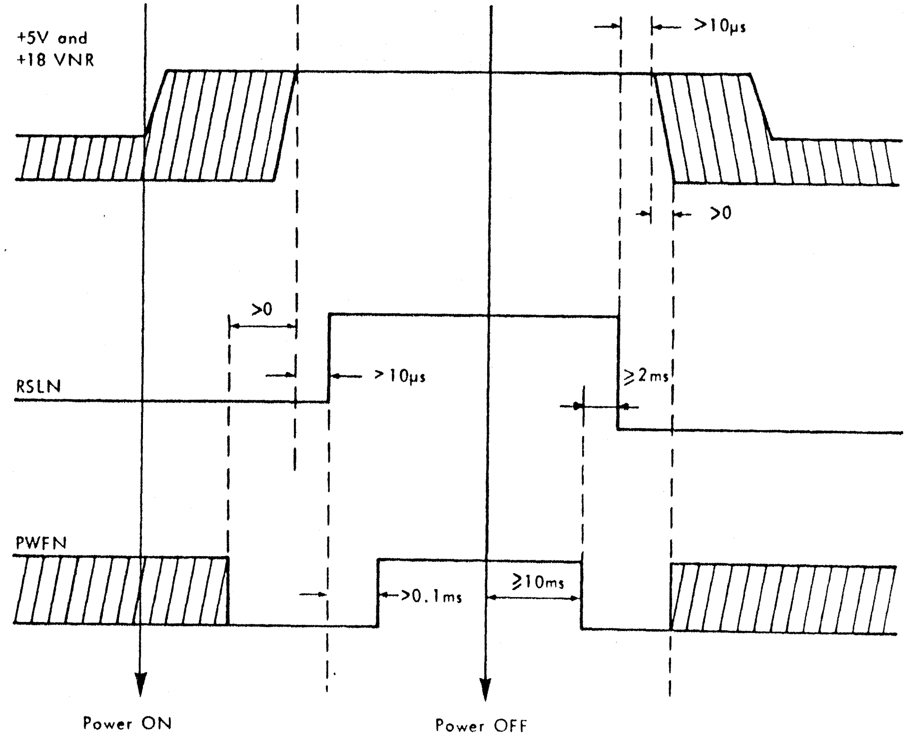


Figure 5-14 Timing Diagram of d.c. Voltages and Logic Signals

5.70 Cabinet Removal and Replacement

Make sure that the cabinet has been disconnected from the mains supply then:

- Remove the protective cover from the power supply by removing the four retaining screws and lifting the cover clear of the cabinet.
- Remove the blank front panel by unscrewing the two Allen screws and lifting clear.
- Remove the cabinet's four retaining screws and pull it towards you until the telescopic slides are fully extended.
- Disconnect the I/O cables.
- Turn the two fixed slide retaining screws (one for each telescopic slide), one half turn in either direction until the fixed slide spigot is free.
- Pull the cabinet towards you until it is clear of the telescopic slides.

The cabinet can be replaced using the above instructions in the reverse order.

5.71 Power Supply Sub-Assemblies

The following paragraphs describe the removal of the five power supply sub-assemblies.

5.72 Sequence Card (REG E2)

Remove the four retaining screws and unplug the card from the connector.

5.73 Power Block

Remove the Sequence card, then remove the card mounting plate by unscrewing the three retaining screws, then:

- Disconnect the input leads from the transformer making a careful note of their positions.
- Disconnect the output leads from the power block making a careful note of their positions.
- Remove the retaining screws (underneath the cabinet) and lift the Power Block clear of the cabinet.

The Power Block can be replaced using the above instructions in the reverse order.

5.74 Mains Transformer

Remove the Sequence card and the card mounting plate, then:

- Disconnect the input and output leads of the transformer making a careful note of their positions.
- Remove the four retaining screws (underneath the cabinet) and lift the transformer clear of the cabinet.

The transformer can be replaced using the above procedure in the reverse order.

5.75 Mains Filter and Local/Remote Switch

Remove the Sequence card and the card mounting plate, then:

- Remove the fuse and Local/Remote switch by unscrewing their locknuts.
- Disconnect the input leads to the transformer making a careful note of their positions.
- Remove the relay mounting plate retaining screws (located on the side of the cabinet).
- Remove the two filter retaining screws and the mains lead clamp, then lift the assembly clear of the cabinet.

The mains filter and Local/Remote switch can be replaced by carrying out the above procedure in the reverse order.

5.76 Fan Unit

Remove the Sequence card and card mounting plate and disconnect the fan leads from the transformer, then:

- Remove the top protective cover (over the control unit cards) and remove the control unit cards.
- Remove the four fan retaining screws and lift the fan clear of the cabinet.

The fan unit is replaced using the above procedure in the reverse order.

5.77 COMPONENTS

Figure 5-16 shows the component layout of the Power Block, Overvoltage Card, Mains Filter and Local/Remote switch assemblies and Tables 5-2 to 5-4 list the components. Figure 5-17 shows the component layout of the Sequence card and Table 5-5 lists the components.

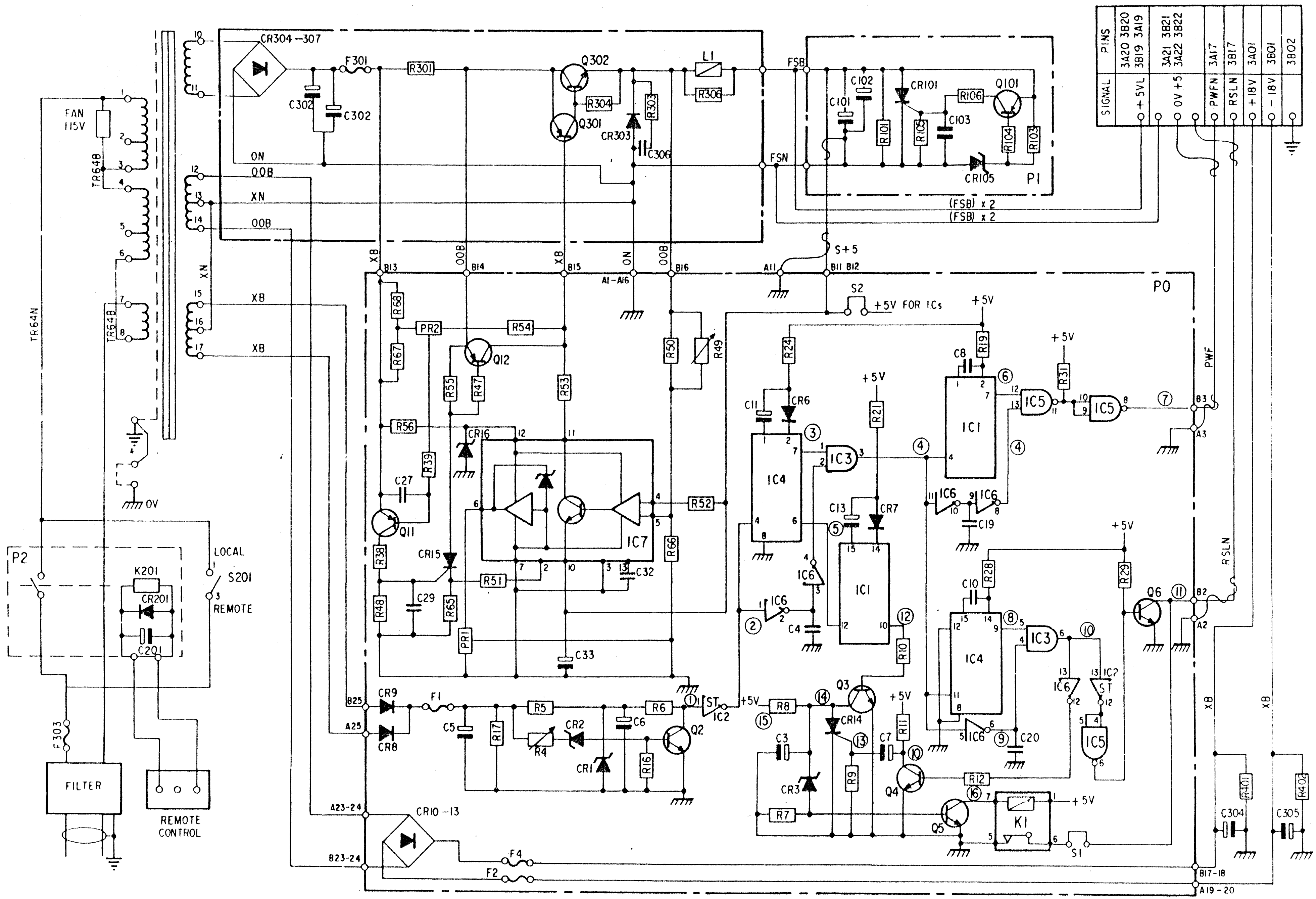


Figure 5-15 Schematic Diagram Power Supply Equipment Shelf

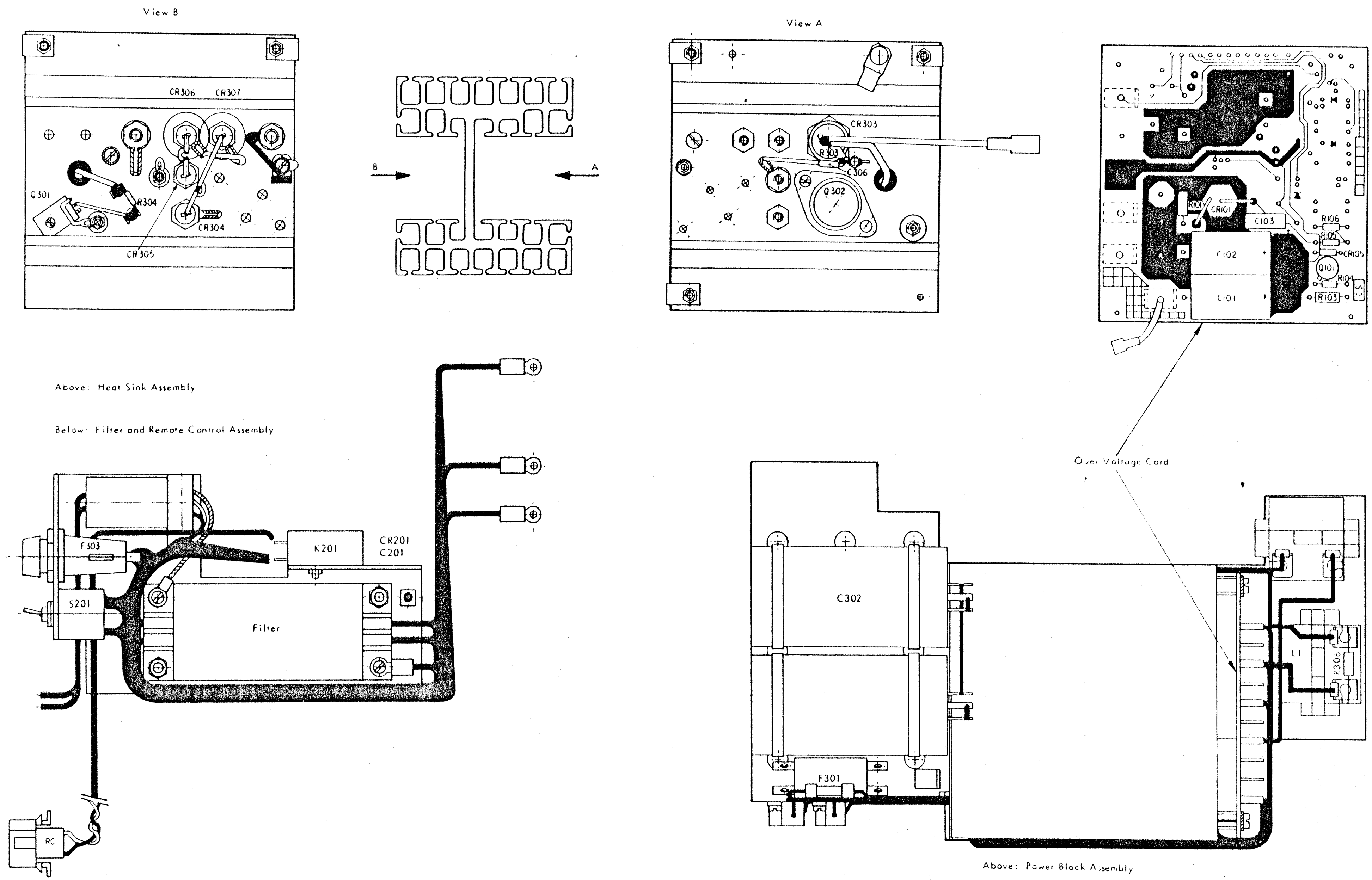


Figure 5-16 Power Supply Component Location

Table 5-2 Power Block Parts List

Reference	Description	12NC Code
	Heat Sink	5111 199 78070
	Harness	5111 199 78060
R304.	Resistor 22n, 0.5W, 5%.	
R303.	Resistor 4.7n, 0.5W, 5%.	
C306.	Capacitor 0.1µF, 100V, PMA.	

Table 5-3 Overvoltage Card Parts List

Reference	Description	12NC Code
	Printed circuit	5111 100 05404
R103.	Resistor 46.4n, 0.25W, 1%.	
R104.	Resistor 100n, 0.25W, 5%.	
R101.	Resistor 560n, 0.25W, 5%.	
R105.	Resistor 270n, 0.25W, 5%.	
R106.	Resistor 10n, 0.25W, 5%.	
C101,102.	Capacitor 1500µF, 10V, elect.	
C103.	Capacitor 0.1µF, 100V, 10%, MPR.	
CR105.	Zener Diode BZX79 C5V6.	
CR101.	Thyristor BTW47 — 600RM.	
Q101.	Transistor 2N2906.	

Table 5-4 Filter and Local/Remote Switch Parts List

Reference	Description	12NC Code
	Mains Filter B84 102 C150.	
	Capacitor B81711 A B25.	
K201.	Relay KS-N V23016-A0002-A101.	
S201.	Switch 6AT2.	
CR201.	Diode BAX12.	
C201.	Capacitor 47µF, 10V, Fitco.	

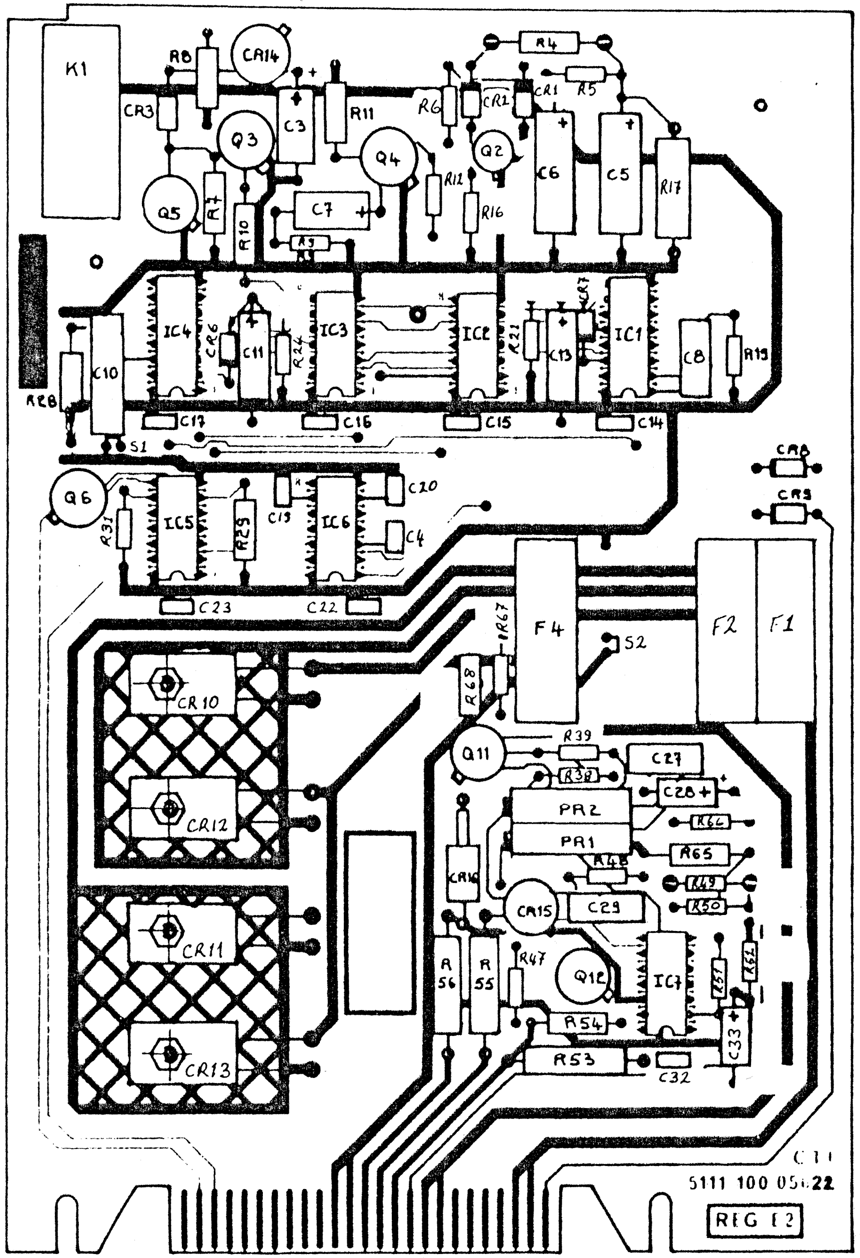


Figure 5-17 Sequence Card Component Layout

Table 5-5 Sequence Card Parts List

Reference	Description	12NC Code
	Printed Circuit	5111 100 05622
IC5.	Integrated circuit 1801.	
IC6.	Integrated circuit 7404.	
IC3.	Integrated circuit 7408.	
IC2.	Integrated circuit 7414.	
IC4, IC1.	Integrated circuit 9602.	
IC7.	Integrated circuit U6A 772 3393.	
Q2.	Transistor BSX20.	
Q6.	Transistor BSX60.	
Q11, Q12.	Transistor 2N2905.	
Q3, Q4, Q5.	Transistor 2N2219.	
CR14.	Transistor 2N1595.	
CR16.	Zener Diode BZV16C15.	
CR1.	Zener Diode BZX79C4V7.	
CR2.	Zener Diode BZX79C7V5.	
CR6, CR7.	Diode BAX13.	
CR8, CR9.	Diode BAX12.	
CR3.	Diode 1N746A.	
CR10, CR11.	Diode BYX49 - 300.	
CR12, CR13.	Diode BYX49 - 300R.	
K1.	Relay MRMD 15005.	
PR1.	Potentiometer 2600 P102 1000.	
PR2.	Potentiometer 2600 P101 100.	
CR15.	Thyristor 2N2323.	
F2, 4.	Fuse DITD/3.15.	
F1.	Fuse DITD/0.31.	
R65.	Resistor 100Ω, 0.25W, 1%.	
R67.	Resistor 22Ω, 0.25W, 5%.	
R9, 12, 31, 48, 51, 52, 66.	Resistor 1KΩ, 0.25W, 5%.	
R47.	Resistor 8.2KΩ, 0.25W, 5%.	
R16.	Resistor 820Ω, 0.25W, 5%.	
R24.	Resistor 30KΩ, 0.25W, 5%.	
R6.	Resistor 2.7KΩ, 0.25W, 5%.	
R39.	Resistor 100Ω, 0.25W, 5%.	
R28.	Resistor 19.6KΩ, 0.25W, 1%.	
R5.	Resistor 2KΩ, 0.25W, 5%.	
R21.	Resistor 24KΩ, 0.25W, 5%.	
R19.	Resistor 12KΩ, 0.25W, 5%.	
R54.	Resistor 150Ω, 0.5W, 5%.	
R7, 10, 11.	Resistor 300Ω, 0.5W, 5%.	
R8, 29.	Resistor 100Ω, 0.5W, 5%.	
R53.	Resistor 390Ω, 1W, 5%.	
R55.	Resistor 2.2KΩ, 1W, 5%.	

Table 5-5 contd.

Reference	Description	12NC Code
R17.	Resistor 1KΩ, 1W, 5%.	
R50.	Resistor 4.7MΩ, 0.25W, 10%.	
R56.	Resistor 820Ω, 1W, 5%.	
R38.	Resistor 1KΩ, 0.25W, 5%.	
R49.	Adjustable Resistor 470KΩ-3.3MΩ, 0.25W.	
R4.	Adjustable Resistor 1KΩ-10KΩ, 0.25W, 1%.	
R68	Thermistor CTN B 832001/P50E.	
C8,29.	Capacitor 0.1µF, 100V, 10%, MPR.	
C27.	Capacitor 0.01µF, 250V, 10%, MPR.	
C10.	Capacitor 0.47µF, 100V, 10%, MPR.	
C32.	Capacitor 100pF, 63V, 2%, ceramic.	
C4,19,20.	Capacitor 470pF, 100V, 10%, ceramic.	
C7.	Capacitor 1µF, 63V, Fitco.	
C3.	Capacitor 47µF, 10V, Fitco.	
C5.	Capacitor 57µF, 25V, Fitco.	
C6.	Capacitor 100µF, 10V, Fitco.	
C28,33.	Capacitor 4.7µF, 10V, CTS13.	
C13.	Capacitor 22µF, 16V, CTS13.	
C14-17,22,23.	Capacitor 3900pF, 100V, 10%.	
C11.	Capacitor 33µF, 10V, CTS13.	