

HP 13220
POWER SUPPLY MODULE
Manual Part No. 13220-91019
REVISED
SEP-10-79

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NOTE: This document is part of the 262XX DATA TERMINAL product series Technical Information Package (HP 13220).

Table 2.0 Reliability and Environmental Information

Environmental: (X) HP Class B () Other:
Restrictions: Type tested at product level
Failure Rate: 2.277 (percent per 1000 hours)

1.0 INTRODUCTION.

The Power Supply Module generates the following voltages: +16 volts at 8.0 amperes, +12 volts at 8.0 amperes, +5 volts at 8.0 amperes, and -12 volts at 0.5 amperes; constrained that the total output power shall not exceed 125 watts. The Power Supply Module also provides a TTL level signal indicating power-on and power-fail warning.

2.0 OPERATING PARAMETERS.

A summary of operating parameters for the Power Supply Module is contained in tables 1.0 through 3.0.

Table 1.0 Physical Parameters

Part Number	Nomenclature	Size (L x W x D) +/-0.100 Inches	Weight (Pounds)
02620-60U19	Power Supply PCA	14.20 x 7.10 x 3.10	4.10

3.0 FUNCTIONAL DESCRIPTION.

Refer to the block diagram (figure 1), schematic diagram (figure 2), timing diagram (figure 3), component location diagram (figure 4), and parts list (U262U-6U019) located in the appendix.

The Power Supply Module employs primary (off-line) switching to create + and - 16VDC sources. The -16V source is linearly regulated to create a -12V output, while the +16V source powers +12V and +5V switching regulators as well as being an output. Internal protection circuitry guards against under and over-voltage conditions. The logic signal interface consists of a Sync circuit which synchronizes the Power Supply Module switching rate to the video sweep rate, and a Power-On circuit which indicates that supply outputs are in regulation and warns of impending loss of regulation.

3.1 PRIMARY SWITCHER.

The Primary (Off-Line) Switcher section of the Power Supply Module consists of the Line Rectifier, Primary Switcher, Secondary Rectifier, and the Primary Switching Regulator blocks shown in figure 1. Together these blocks transform power taken from the AC line to isolated + and - 16VDC sources.

3.1.1 Line Rectifier

The Line Rectifier connects to the power line via the Power Panel Assy., and rectifies and filters the incoming AC power. Line voltage selection is determined by fuse location which configures the Line Rectifier as either a voltage-doubler (115VAC operation) or as a full-wave bridge (230VAC operation). Output voltage is + and - 150VDC at nominal line.

3.1.2 Primary Switcher

The Primary Switcher block uses a half-bridge topology to power switching transformer T2. Two power transistors (Q1 and Q2) are driven alternately by the Primary Switching Regulator via base-drive transformer T3. These transistors switch the primary of T2 between the + and - 150V outputs of the Line Rectifier. Regulation is achieved through pulse-width modulation, as the average output voltage of transformer T2 is proportional to the duty cycle of Q1 and Q2. Diodes CR4 and CR5 clamp the primary of T2 to prevent voltage over-shoot.

3.1.3 Secondary Rectifier

This block rectifies and filters the output of switching transformer T2, using inductor input LC filters. A bipolar output is produced by using a full-wave bridge rectifier with a center-tapped secondary winding. Resistor R38 produces a voltage proportional to load current for current-limit sensing. Diodes CR16 and CR17 together with resistors R41 and R42 form an OR gate, whose output voltage remains high whenever switching transistors Q1 and Q2 overlap in conduction.

Table 3.0 Connector Information - Power Supply PCA

Connector and Pin No.	Signal Name	Signal Description
J1, Pin 1	Ground) Power connection for fan
2	Line Neutral	
3	115VAC	
4	Reserved	
J2 Pin 1	Line In) Input power from Power Panel Assy
2	Line Neutral	
3	Ground	
J3 Pin 1,2	+16V) Power connection to TPM PCA
3,4	Ground	
J4 Pin 1	+16V) Power connection reserved for expansion
2	Key	
3	+12V	
4,5	+5V	
6,7,8	Ground	
9	-12V	
J5 Pin 1,3	+5V	
2	Key	
4	+12V	
5,6	Return	
7	Power On/Fail	
8	-12V	
J6 Pin 1	+5V) Power connection to Sweep PCA
2	Key	
3	+12V	
4	Return	
5	Sync	

3.2 SECONDARY REGULATION.

The Secondary Regulation section of the Power Supply Module consists of the -12 Volt Linear Regulator, +12 Volt Switching Regulator, and +5 Volt Switching Regulator blocks shown in figure 1.

3.2.1 -12 Volt Linear Regulator

This block is composed of a 7812 three-terminal -12 volt regulator IC and output bypass capacitor C29. The 7812 incorporates internal thermal and current-limit protection. Output voltage is fixed, and therefore independent of the "Voltage Control" R71.

3.2.2 +12 Volt Switching Regulator

The +12 Volt Switching Regulator is powered by the +16 volt output of the Secondary Rectifier. Switch timing and voltage reference are derived from the Primary Switching Regulator.

The main switching element is Q5, a hybrid circuit containing a darlington transistor and power diode. When the darlington transistor is turned on, current flows from the +16 volt supply through inductor L2 and into the output filter capacitors C46 and C47. When the darlington transistor is turned off, the current flowing through L2 and C46 and C47 continues to flow through the power diode in Q5. The output voltage is regulated by controlling the duty cycle of the darlington transistor in Q5.

Inductor L4 and diode CR29 limit the input current while Q5 is turning on, and capacitor C40 with its associated resistor and diode hold off the output voltage while Q5 is turning off. Together these two circuits substantially reduce switching noise and power dissipation in Q5. Diode CR7 protects the darlington transistor in Q5 from reverse bias breakdown should a short to ground occur on the +16 volt output.

Voltage regulation is accomplished by feeding back a fraction of the output voltage and comparing it to a 2.5V reference. The difference between the feedback voltage and the reference voltage is amplified by differential amplifier U7 to create a switching reference voltage. Comparator U6 compares the switching reference voltage to a linear ramp voltage. The comparator turns on current sink Q7 until the ramp voltage exceeds the switching reference at which time it turns off Q7. Current sink Q7 provides base drive for the darlington transistor in Q5, and therefore controls switching operation. In effect, the output of comparator U6 is pulse-width modulated by the amplified error voltage. Capacitors C33, C34, and C48, and resistors R25 and R75 determine the transient response and stability of the +12 volt regulator. Diodes CR35-37 clamp the switching reference voltage (output of differential amplifier U7) to a maximum of 4.3 volts, preventing voltage overshoot at turn-on.

3.1.4 Primary Switching Regulator

This block controls the Primary Switcher section of the Power Supply Module. The heart of this block is U11, an SG3524 regulator IC. The SG3524 is a fixed-frequency pulse-width modulation voltage regulator circuit. The operating frequency is programmed by timing resistor R44 and timing capacitor C7. R44 establishes a constant charging current for C7, producing a linear voltage ramp. Internally, the SG3524 compares this linear ramp to the output of a feedback error amplifier. The result of this comparison is a fixed-frequency pulse train whose duty cycle (ratio of on-to-off time) is linearly proportional to the error amplifier's output. The modulated pulse train toggles an internal pulse steering flip-flop, which in turn alternately powers two open-collector outputs, C1 and C2. The C1 and C2 outputs of the SG3524 are buffered by Q3 and Q4, respectively, which in turn power the primary of base-drive transformer T3.

The SG3524 contains an internal 5 volt linear regulator which powers external CMOS ICs, as well as acting as a voltage reference. Potentiometer R71 together with resistors R67 and R70 create a 2.5V reference from the 5V output of the SG3524. Since this 2.5V reference is used by the +12V and +5V switching regulators as well, the +16V, 12V, and +5V outputs are all proportionally varied by adjusting potentiometer R71 (labeled "Voltage Control").

An internal current-limit circuit in the SG3524 inhibits switching operation when the secondary current of switching transformer T2 exceeds 11 amps.

The SG3524 provides an oscillator input/output which is high once each cycle during the discharge time of timing resistor C7. This oscillator output also serves as a blanking pulse, inhibiting both C1 and C2 outputs.

During low-line conditions, the duty-cycle of the output pulses at C1 and C2 of the SG3524 will approach 50%. A 50% duty-cycle drive to switching transistors Q1 and Q2 will result in destructive conduction overlap, due to the storage-time of these transistors. To prevent this from occurring the overlap output from the Secondary Rectifier is used to force the SG3524's oscillator output high, thereby inhibiting both C1 and C2 outputs. After the transistor storage-time has elapsed, the overlap signal will return low allowing the oscillator output to go low.

Transistor Q9 and OP amp U8 together with the related circuitry form a power-on soft-start circuit. This circuit ensures that switching operation is disabled at turn-on until the bootstrap supply voltage reaches approximately 4.5V. At this time the C1 and C2 outputs of U11 are allowed to increase from zero to full duty-cycle.

The Over-Voltage Shut Down circuit is manually reset by turning the AC line switch off and then back on. It is generally possible to engage the Over-Voltage Shut Down circuit by adjusting the Voltage Control, R71, fully CW.

3.3.2

Under-Voltage Shut Down

The Under-Voltage Shut Down circuit monitors the voltage of the +16V output. If the +16V output voltage drops below +13V, Resistor R46 will begin charging capacitor C25. If the +16V output remains below +13V for more than approximately two seconds, capacitor C25 will charge above 5.1V and comparator U5 will pull the compensation input of the switching regulator U11 to ground. This shuts down the Primary Switching Regulator, and hence the entire supply. Resistor R47 and capacitor C19 reduce the sensitivity of the Under-Voltage Shut Down circuit to switching noise present on the +16V output.

The Under-Voltage Shut Down circuit is manually reset by turning the AC line switch off and then back on.

3.4

LOGIC SIGNAL INTERFACE.

The logic signal interface consists of a Sync circuit which synchronizes the Power Supply Module's switching rate to the video sweep rate, and a Power-On circuit which indicates that supply outputs are in regulation and warns of impending loss of regulation.

3.4.1

Sync Circuit

The Sync Circuit is a digital phase-locked-loop which synchronizes the power supply switching rate to twice the video sweep rate. Lock-in range is restricted to input sync signals in the range of 20 to 30kHz, corresponding to power supply switching rates of 40 to 60kHz. Synchronizing the power supply switching rate to the video sweep prevents switching noise from appearing on the terminal's CRT display.

Toggle flip-flop U9 divides the "OSC" output frequency of switching regulator U11 by two to create a feedback signal for digital phase comparator U10. U10 compares this feedback signal to the input sync signal and produces an output voltage proportional to the phase error between these two signals. Resistor R50 and capacitor C21 form a single pole low pass filter, which determines the transient response and stability of the Sync Circuit. Operational amplifier U8 and resistor R43 form a non-inverting voltage-to-current buffer. The output current of this buffer varies the operating frequency of switching regulator U1 by varying the current flowing through timing resistor R44. The frequency lock range of the Sync Circuit is limited by the output voltage range of buffer amplifier U8.

Output current is sensed by comparator U2 across R72. The point of current limit is set by resistors R13 and R17 (8 amps). A foldback characteristic is obtained since the +12 volt output forms part of the current limit reference, and as it decreases due to current limit the current limit reference also decreases. The latch formed by U5 is set by the output of comparator U2 and inhibits the switching regulator from supplying current until the "OSC" output of the SG3524 switching regulator (U11) resets the latch. This prevents the current limit circuit from oscillating.

Comparator U2 disables the +12 volt switching regulator in the event of a short to ground on the -12 volt output.

3.2.3 +5 Volt Switching Regulator

The operation of the +5 Volt Switching Regulator is identical to that of the +12 Volt Switching Regulator with the following exceptions. Output voltage of the +5V supply is limited to 6.19V by zener diode CR31. This prevents the output voltage from rising high enough to damage the load before the Over-Voltage Shut Down circuit can disable the Primary Switching Regulator. Operation of the +5 Volt Switching Regulator is inhibited by comparator U2 whenever the +12V output drops below 10V.

3.3 PROTECTION CIRCUITRY.

Active circuitry is employed to guard against over and under-voltage conditions on the Power Supply Module's +16V, +12V, and +5V outputs.

3.3.1 Over-Voltage Shut Down

The Over-Voltage Shut Down circuit monitors the +16V, +12V, and +5V outputs for abnormally high voltage. The over-voltage thresholds are set at +17.2V, +13.4V, and +5.6V respectively.

Resistors R28 and R29 form a voltage divider from the +16V output. The output of this divider is compared by U6 to a 5.1v reference provided by the Bootstrap Supply. If the +16V output should rise above +17.2V, the output of comparator U6 will be pulled up by R11, which in turn nulls up, through CR24, the non-inverting input of comparator U5. This will cause the output of comparator U5 to go high and be latched high by CR22. With the output of U5 latched high, the shut-down input of the SG3524 switching regulator (U11) will be held high, and the Primary Switcher disabled.

The +12V and +5V outputs are monitored in a similar manner to that of the +16V output. The +5V output monitor uses a diode forward voltage drop above the 5.1v reference to establish the over-voltage threshold. Capacitors C27, C30, and C31 reduce the sensitivity of the Over-Voltage Shut Down circuit to switching noise and electrostatic discharge.

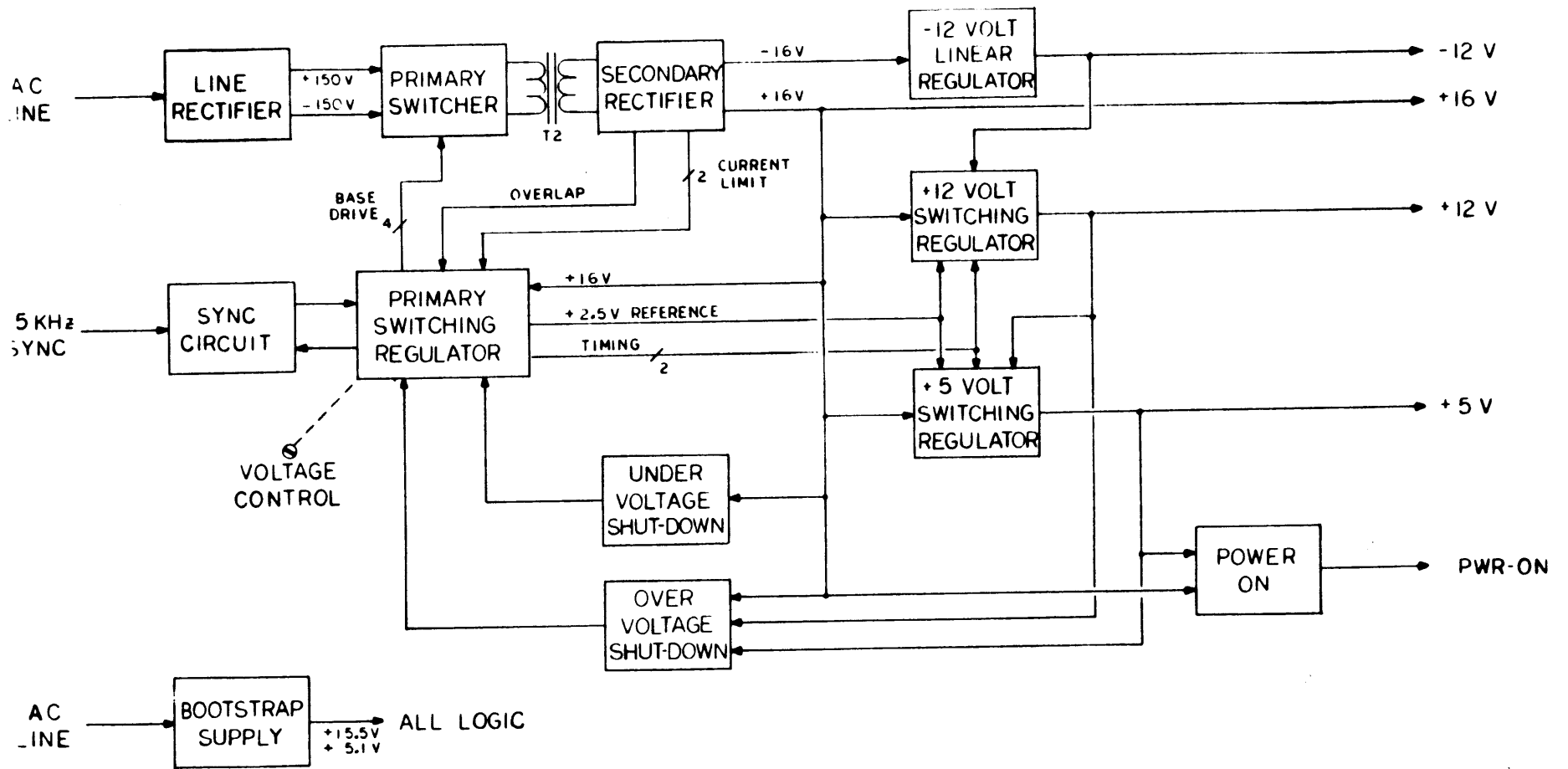


Figure 1
 Power Supply Module Block Di
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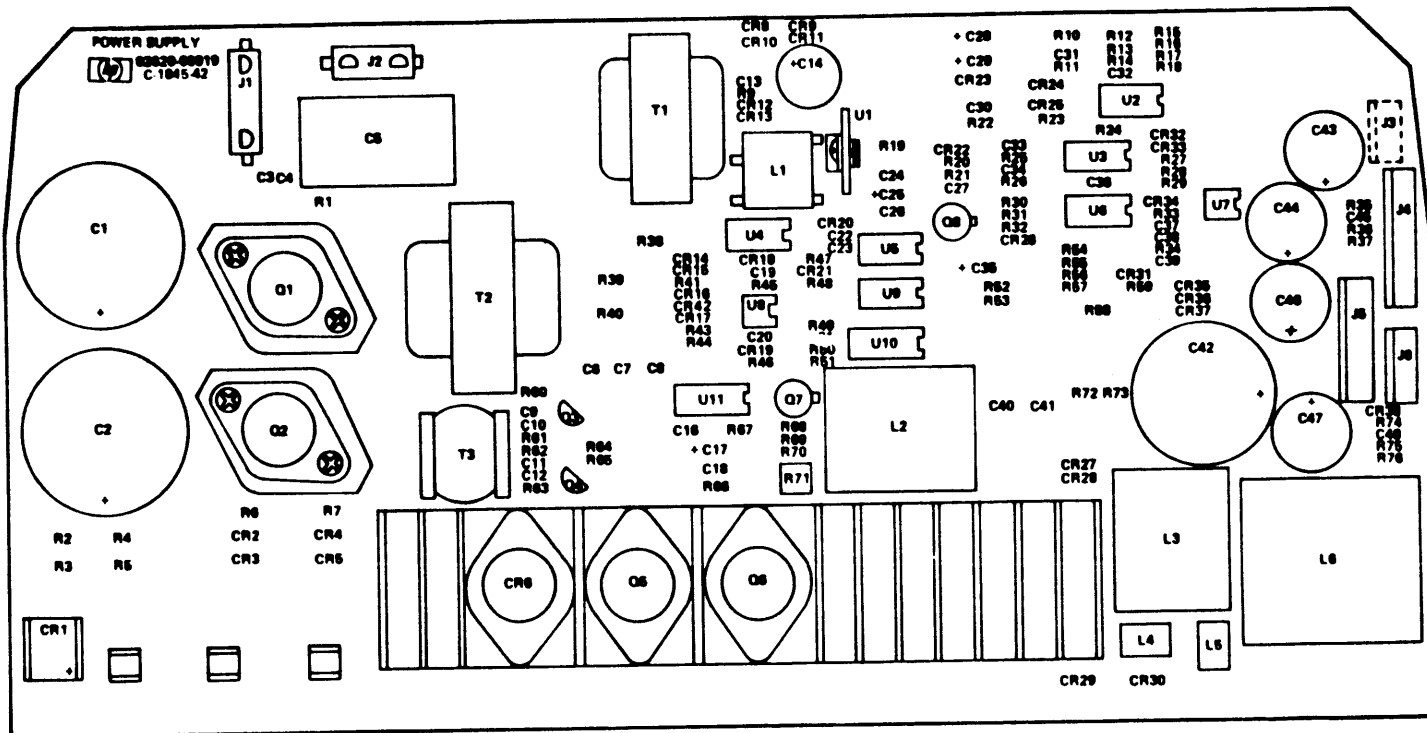


Figure 3
Power Supply PCA Component Location Diagram
SEP-10-79
13220-91010

Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	02620-00010	7	1	POWER SUPPLY, PCA DATE CODE: D-1917-42	20400	02620-00010
C1	0100-2940	3	2	CAPACITOR-FXD 780UF+50-10% 200VDC AL	20400	0100-2940
C2	0100-2940	3	2	CAPACITOR-FXD 780UF+50-10% 200VDC AL	20400	0100-2940
C3	0100-3456	0	2	CAPACITOR-FXD 1000PF +-10% 1KVDC CER	20400	0100-3456
C4	0100-3456	0	2	CAPACITOR-FXD 1000PF +-10% 1KVDC CER	20400	0100-3456
C5	0100-4242	0	1	CAPACITOR-FXD .01UF +-10% 200VDC MET-POLY	20400	0100-4242
C6	0100-0102	5	2	CAPACITOR-FXD .022UF +-10% 200VDC POLYE	20400	0100-0102
C7	0100-0102	5	2	CAPACITOR-FXD .022UF +-10% 200VDC POLYE	20400	0100-0102
C8	0100-0101	0	1	CAPACITOR-FXD .01UF +-10% 200VDC POLYE	20400	0100-0101
C9	0100-3335	0	4	CAPACITOR-FXD 470PF +-10% 100VDC CER	20400	0100-3335
C10	0100-4554	0	14	CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C11	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C12	0100-3335	0		CAPACITOR-FXD 470PF +-10% 100VDC CER	20400	0100-3335
C13	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C14	0100-2913	0	1	CAPACITOR-FXD 470UF+50-10% 50VDC AL	20400	0100-2913
C16	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C17	0100-2879	7	5	CAPACITOR-FXD 22UF+50-10% 25VDC AL	20400	0100-2879
C18	0100-0157	0	1	CAPACITOR-FXD 4700PF +-10% 200VDC POLYE	20400	0100-0157
C19	0100-4557	0	7	CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
C20	0100-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
C21	0100-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
C22	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C23	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C24	0100-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
C25	0100-2879	7		CAPACITOR-FXD 22UF+50-10% 25VDC AL	20400	0100-2879
C26	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C27	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C28	0100-2879	7		CAPACITOR-FXD 22UF+50-10% 25VDC AL	20400	0100-2879
C29	0100-2879	7		CAPACITOR-FXD 22UF+50-10% 25VDC AL	20400	0100-2879
C30	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C31	0100-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
C32	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C33	0100-3335	0		CAPACITOR-FXD 470PF +-10% 100VDC CER	20400	0100-3335
C34	0100-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
C35	0100-2879	7		CAPACITOR-FXD 22UF+50-10% 25VDC AL	20400	0100-2879
C36	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C37	0100-3335	0		CAPACITOR-FXD 470PF +-10% 100VDC CER	20400	0100-3335
C38	0100-4557	0		CAPACITOR-FXD .1UF +-20% 50VDC CER	16299	CAC04X7R104M050A
C39	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C40	0100-0300	0	2	CAPACITOR-FXD .22UF +-10% 200VDC POLYE	20400	0100-0300
C41	0100-0300	0	2	CAPACITOR-FXD .22UF +-10% 200VDC POLYE	20400	0100-0300
C42	0100-2941	4	1	CAPACITOR-FXD .012F+-20% 20VDC AL	20400	0100-2941
C43	0100-2000	0	4	CAPACITOR-FXD 2200UF+50-10% 16VDC AL	20400	0100-2000
C44	0100-2000	0	4	CAPACITOR-FXD 2200UF+50-10% 16VDC AL	20400	0100-2000
C45	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
C46	0100-2000	0		CAPACITOR-FXD 2200UF+50-10% 16VDC AL	20400	0100-2000
C47	0100-2000	0		CAPACITOR-FXD 2200UF+50-10% 16VDC AL	20400	0100-2000
C48	0100-4554	7		CAPACITOR-FXD .01UF +-20% 50VDC CER	20400	0100-4554
CR1	1901-0000	0	1	DIODE-PWR BRDG 600V 10A	20400	1901-0000
CR2	1901-0048	7	3		20400	1901-0048
CR3	1901-0048	7			20400	1901-0048
CR4	1901-1005	2	0	DIODE-PWR RECT 1A4036 400V 1A 200MS	14936	1A4036
CR5	1901-1005	2	0	DIODE-PWR RECT 1A4036 400V 1A 200MS	14936	1A4036
CR6	1901-0067	2	1	DIODE-CY-RECT 150V 30A	27777	0754
CR7	1901-1005	2		DIODE-PWR RECT 1A4036 400V 1A 200MS	14936	1A4036
CR8	1901-0050	3	22	DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR9	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR10	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR11	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR12	1902-3094	3	1	DIODE-ZNR 5.11V 2% DO-7 Pwr. 4m TC= .009%	20400	1902-3094
CR13	1901-0731	7	3	DIODE-PWR RECT 400V 1A	20400	1901-0731
CR14	1901-1005	2		DIODE-PWR RECT 1A4036 400V 1A 200MS	14936	1A4036
CR15	1901-1005	2		DIODE-PWR RECT 1A4036 400V 1A 200MS	14936	1A4036
CR16	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR17	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR18	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR19	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR20	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR21	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR22	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR23	1901-0731	7		DIODE-PWR RECT 400V 1A	20400	1901-0731
CR24	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050
CR25	1901-0050	3		DIODE-SWITCHING 80V 200MA 2MS DO-35	20400	1901-0050

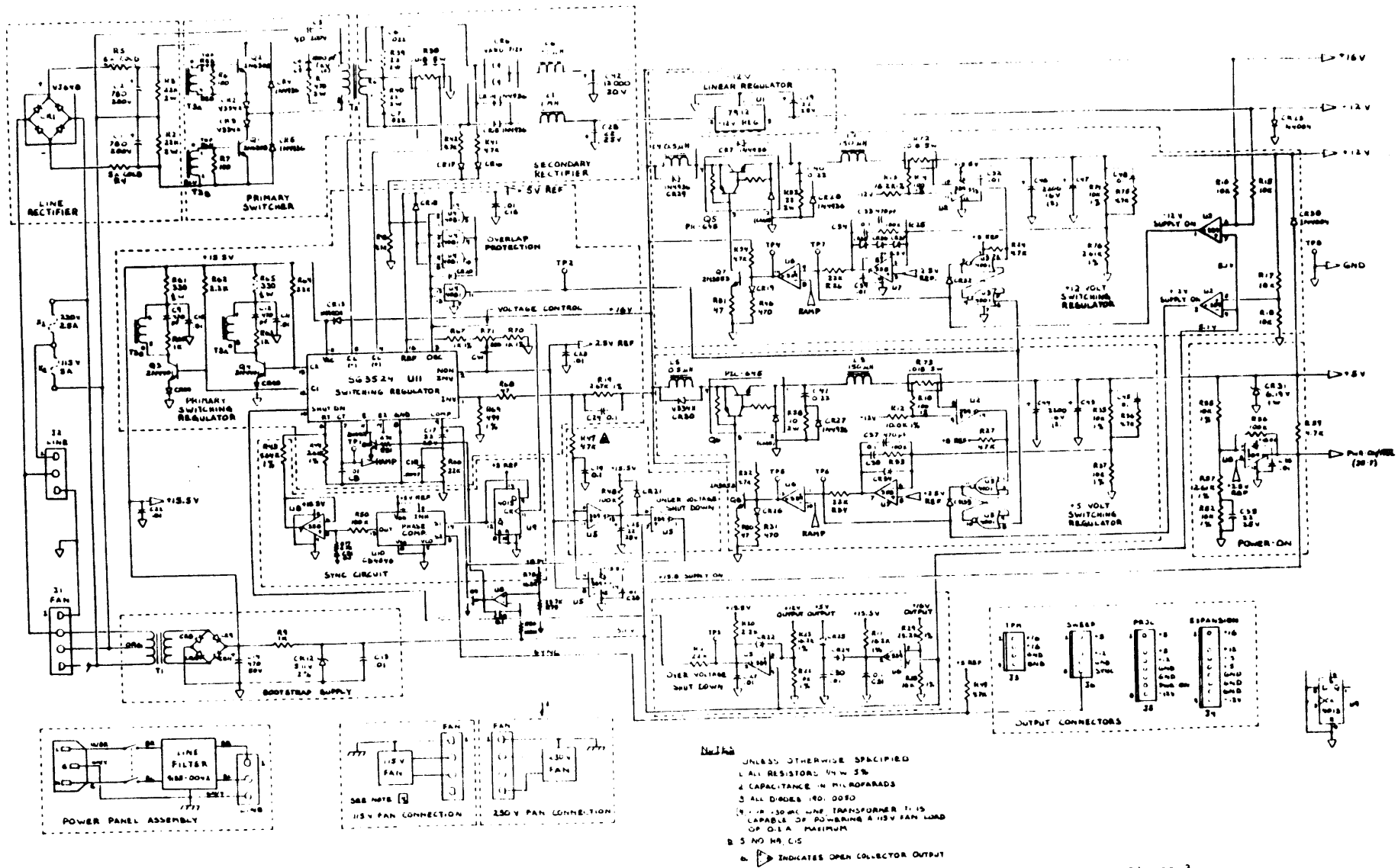


Figure 2
Power supply PCA schematic diagram
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3.4.2 Power-On

The Power-On circuit serves two functions. It senses the output voltage of the +5 Volt Switching Regulator and indicates, by going high, when the +5V output is in regulation. It also senses the voltage on the +16V output and goes low to indicate a power fail condition shortly before the +5 Volt Switching Regulator begins to lose regulation (the +5 Volt Switching Regulator is powered by the +16V output). Comparator U5 monitors the +16V output voltage. When this voltage

drops below +13V, U5 pulls the Power-On/Fail output low. Comparator U6 monitors the +5V output voltage through a voltage divider formed

by resistors R52, R55, and R57. The Power-On/Fail output is pulled low by U6 when the +5V output drops out of regulation. Resistor R56 provides approximately 0.2V of hysteresis to prevent the Power-

On/Fail output from oscillating. Capacitor C35 furnishes a delay at turn on to reset logic circuitry within the terminal.

3.5 ROOTSTRAP SUPPLY.

The Rootstrap Supply operates off the AC power line through transformer T1. It provides the power necessary to start the operation of the Primary Switcher. Once the Primary Switcher is in operation diode CR13 furnishes power to the Rootstrap Supply from the +16V output.

Replaceable Parts

Reference Designation	HP Part Number	C	D	Qty	Description	Mfr Code	Mfr Part Number
R82	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
R83	0098-3195	1		1	RESISTOR 4.68K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-0601-F
R84	0098-0085	0		3	RESISTOR 2.61K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-2011-F
R85	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
R86	0083-4715	0			RESISTOR 470 5% .25W FC TCR=400/+600	01121	CB4715
R87	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
R88	0083-1045	3			RESISTOR 100K 5% .25W FC TCR=400/+800	01121	CB1045
R89	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
R90	0083-1045	3			RESISTOR 100K 5% .25W FC TCR=400/+800	01121	CB1045
R91	0083-4705	0			RESISTOR 47 5% .25W FC TCR=400/+500	01121	CB4705
R92	0757-0442	0			RESISTOR 10K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-1002-F
R93	0098-3609	0			RESISTOR 22 5% 2W MD TCR=+/-200	27167	FP42-2-T00-2200-J
R94	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
R95	0757-0442	0			RESISTOR 10K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-1002-F
R96	0083-1045	3			RESISTOR 100K 5% .25W FC TCR=400/+800	01121	CB1045
R97	0098-0085	0			RESISTOR 2.61K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-2011-F
R98	0098-3609	2		1	RESISTOR 10 5% 2W MD TCR=+/-200	27167	FP42-2-T00-1000-J
R99	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
R00	0083-1025	0			RESISTOR 1K 5% .25W FC TCR=400/+600	01121	CB1025
R01	0086-3315	0		2	RESISTOR 330 5% .5W CC TCR=+/-529	01121	EB3315
R02	0083-2225	3			RESISTOR 2.2K 5% .25W FC TCR=400/+700	01121	CB2225
R03	0083-1025	0			RESISTOR 1K 5% .25W FC TCR=400/+600	01121	CB1025
R04	0083-2225	3			RESISTOR 2.2K 5% .25W FC TCR=400/+700	01121	CB2225
R05	0086-3315	0			RESISTOR 330 5% .5W CC TCR=+/-529	01121	EB3315
R06	0083-2235	5			RESISTOR 22K 5% .25W FC TCR=400/+800	01121	CB2235
R07	0757-0280	3		2	RESISTOR 1K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-1001-F
R08	0083-4705	0			RESISTOR 47 5% .25W FC TCR=400/+500	01121	CB4705
R09	0098-4123	5		1	RESISTOR 499 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-4999-F
R70	0757-0280	0			RESISTOR 1K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-1001-F
R71	2100-3212	3		1	RESISTOR-TRMR 200 10% C TOP=ADJ 1-TRN	20480	2100-3212
R72	0811-3526	2			RESISTOR .010 3% 5W PH TCR=+/-40	20480	0811-3526
R73	0811-3526	2			RESISTOR .010 3% 5W PH TCR=+/-40	20480	0811-3526
R74	0757-0442	9			RESISTOR 10K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-1002-F
R75	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
R76	0098-0085	0			RESISTOR 2.61K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-2011-F
R77	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
R78	0757-0442	4			RESISTOR 16.2K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-1622-F
R79	0098-3195	4			RESISTOR 23.7K 1% .125W F TCR=+/-100	24546	Ca-1/8-T0-2372-F
R80	0083-1045	3			RESISTOR 100K 5% .25W FC TCR=400/+800	01121	CB1045
R81	0083-4725	2			RESISTOR 4.7K 5% .25W FC TCR=400/+700	01121	CB4725
T1	9100-4120	6		1	TRANSFORMER-POWER, 12V	20480	9100-4120
T2	9100-4119	3		1	TRANSFORMER-SWITCHING	20480	9100-4119
T3	9100-4121	7		1	TRANSFORMER-DUAL PULSE	20480	9100-4121
TP1	0360-0124	3		0	CONNECTOR-8BL CONT PIN .04-IN-88C-8Z RND	20480	0360-0124
TP2	0360-0124	3			CONNECTOR-8BL CONT PIN .04-IN-88C-8Z RND	20480	0360-0124
TP3	0360-0124	3			CONNECTOR-8BL CONT PIN .04-IN-88C-8Z RND	20480	0360-0124
TP4	0360-0124	3			CONNECTOR-8BL CONT PIN .04-IN-88C-8Z RND	20480	0360-0124
TP5	0360-0124	3			CONNECTOR-8BL CONT PIN .04-IN-88C-8Z RND	20480	0360-0124
TP6	0360-0124	3			CONNECTOR-8BL CONT PIN .04-IN-88C-8Z RND	20480	0360-0124
TP7	0360-0124	3			CONNECTOR-8BL CONT PIN .04-IN-88C-8Z RND	20480	0360-0124
TP8	0360-0124	3			CONNECTOR-8BL CONT PIN .04-IN-88C-8Z RND	20480	0360-0124
U1	1026-0221	0		1	IC V RBLTR T0-220	04713	MC7012CT
U2	1026-0130	0		3	IC COMPARATOR SP QUAD 14-DIP-P	04713	LM1339P
U3	1026-0946	4		1	IC SATE CMOS NOR QUAD 2-IMP	01920	CD4001AF
U4	1026-1486	0		1	IC SATE CMOS AND QUAD 2-IMP	01920	CD4001BF
U5	1026-0130	0			IC COMPARATOR SP QUAD 14-DIP-P	04713	LM1339P
U6	1026-0130	0			IC COMPARATOR SP QUAD 14-DIP-P	04713	LM1339P
U7	1026-0346	0		2	IC OP AMP SP DUAL 8-DIP-P	27014	LM3504
U8	1026-0346	0			IC OP AMP SP DUAL 8-DIP-P	27014	LM3504
U9	1026-0930	0		1	IC FF CMOS D-TYPE POS-EDGE-TRIG DUAL	01920	CD4013AF
U10	1026-1100	0		1	IC PL LOOP 14-DIP-P	01920	CD4006AF
U11	1026-0020	0		1	IC 3524 MODULATOR 16-DIP-C	01295	883524J
					MISCELLANEOUS PARTS		
	0360-1945	0		0	SCREW-MACH M3 X 0.5 6MM-LG PAN-HD	20480	0360-1945
	0515-0055	0		1	SCREW-MACH M3.5 X 0.6 10MM-LG PAN-HD	20480	0515-0055
	0515-0067	2		0	SCREW-MACH M3.5 X 0.6 10MM-LG PAN-HD	20480	0515-0067
	0515-0060	3		7	SCREW-MACH M3.5 X 0.6 10MM-LG PAN-HD	20480	0515-0060
	0535-0060	0		1	NUT-MEX DBL-CHEM M3 X 0.5 2.0MM-TMK	00000	ORDER BY DESCRIPTION
	0535-0007	2		7	NUT-MEX DBL-CHEM M3.5 X 0.6 2.0MM-TMK	00000	ORDER BY DESCRIPTION
	0626-0411	1		1	SCREW-TYPE 6-19 .313-IN-LG PAN-HD=POZI	00000	ORDER BY DESCRIPTION
	0890-0732	2		1	TUBING-MS .063-ID/.031-REVD .017-WALL	20480	0890-0732
	1200-0077	0		1		20480	1200-0077
	1200-0105	0		2	INSULATOR-IBTR NYLON	20480	1200-0105

Replaceable Parts

Reference Designation	HP Part Number	C	D	Qty	Description	Mfr Code	Mfr Part Number
CR26	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
CR27	1901-1065	2			DIODE-PWR RECT 1N4936 400V 1A 200N8	14936	1N4936
CR28	1901-1065	2			DIODE-PWR RECT 1N4936 400V 1A 200N8	14936	1N4936
CR29	1901-1065	2			DIODE-PWR RECT 1N4936 400V 1A 200N8	14936	1N4936
CR30	1901-0048	7			DIODE-PWR RECT 1N4936 400V 1A 200N8	28480	1901-0048
CR31	1902-0551	1		1	DIODE-2NR 6.19V 5% DO-15 PDB1N TC=+.022%	28480	1902-0551
CR32	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
CR33	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
CR34	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
CR35	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
CR36	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
CR37	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
CR38	1901-0731	7			DIODE-PWR RECT 400V 1A	28480	1901-0731
CR39	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
CR40	1901-0050	3			DIODE-SWITCHING 80V 200MA 2N8 DO-35	28480	1901-0050
J1	1251-3037	1		1	CONNECTOR 4-PIN M UTILITY	28480	1251-3037
J2	1251-0781	1		1	CONNECTOR 3-PIN M UTILITY	00779	350780-1
J3	1251-3195	4		1	CONNECTOR 8-PIN M POST TYPE	28480	1251-3195
J4	1251-5522	5		1	CONNECTOR 8-PIN M POST TYPE	28480	1251-5522
J5	1251-5520	3		1	CONNECTOR 7-PIN M POST TYPE	28480	1251-5520
J6	1251-5510	0		1	CONNECTOR 4-PIN M POST TYPE	28480	1251-5510
L1	9140-0344	2		1	COIL 800UH	28480	9140-0344
L2	9140-0314	0		2	COIL 100UH	28480	9140-0314
L3	9140-0314	0		0	COIL 100UH	28480	9140-0314
L4	9140-0341	0		2	COIL 500NH .3DX,5LG-NQM	28480	9140-0341
L5	9140-0341	0		0	COIL 500NH .3DX,5LG-NQM	28480	9140-0341
L6	9140-0340	8		1	COIL 100UH	28480	9140-0340
Q1	1854-0467	5		3	TRANSISTOR NPN 2N4401 SI TO-92 PDB310MH	04713	2N4401
Q2	1854-0467	5		2	TRANSISTOR NPN 2N4401 SI TO-92 PDB310MH	04713	2N4401
Q3	1854-0467	6		1	TRANSISTOR NPN 2N4401 SI TO-92 PDB310MH	04713	2N4401
Q4	1854-0467	6		1	TRANSISTOR NPN 2N4401 SI TO-92 PDB310MH	04713	2N4401
Q5	1813-0114	3		2	IC-LINEAR	12969	PIC045
Q6	1813-0114	3		1	IC-LINEAR	12969	PIC045
Q7	1854-0090	0		2	TRANSISTOR NPN SI TO-39 PDB1N FTM100MHZ	28480	1854-0090
Q8	1854-0090	0		0	TRANSISTOR NPN SI TO-39 PDB1N FTM100MHZ	28480	1854-0090
Q9	1854-0466	4		1	TRANSISTOR J-FET P-CHAN D-MODE SI	32293	3T110
Q10	1854-0467	5		1	TRANSISTOR NPN 2N4401 SI TO-92 PDB310MH	04713	2N4401
R1	0698-3034	1		1	RESISTOR 470 5% 2W MO TC=+200	28480	0698-3034
R2	0764-0045	3		2	RESISTOR 22K 5% 2W MO TC=+200	28480	0764-0045
R3	0764-0045	3		2	RESISTOR 22K 5% 2W MO TC=+200	28480	0764-0045
R4	0037-0135	7		2	RESISTOR 10K 1% .125W F TC=+100	24546	CA-1/8-T0-101-F
R5	0037-0135	7		2	RESISTOR 10K 1% .125W F TC=+100	24546	CA-1/8-T0-101-F
R6	0683-1015	7		2	RESISTOR 100 5% .25W FC TC=+400/+500	01121	CB1015
R7	0683-1015	7		2	RESISTOR 100 5% .25W FC TC=+400/+500	01121	CB1015
R8	0683-1025	0		3	RESISTOR 1K 5% .25W FC TC=+400/+500	01121	CB1025
R9	0757-0441	0		2	RESISTOR 100 1% .125W F TC=+100	24546	CA-1/8-T0-101-F
R10	0757-0441	0		2	RESISTOR 100 1% .125W F TC=+100	24546	CA-1/8-T0-101-F
R11	0757-0447	0		4	RESISTOR 10.2K 1% .125W F TC=+100	24546	CA-1/8-T0-1022-F
R12	0757-0447	0		0	RESISTOR 10.2K 1% .125W F TC=+100	24546	CA-1/8-T0-1022-F
R13	0757-0447	0		0	RESISTOR 10.2K 1% .125W F TC=+100	24546	CA-1/8-T0-1022-F
R14	0757-0441	0		0	RESISTOR 100 1% .125W F TC=+100	24546	CA-1/8-T0-101-F
R15	0683-1035	1		4	RESISTOR 10K 5% .25W FC TC=+400/+700	01121	CB1035
R16	0683-1035	1		1	RESISTOR 10K 5% .25W FC TC=+400/+700	01121	CB1035
R17	0683-1035	1		1	RESISTOR 10K 5% .25W FC TC=+400/+700	01121	CB1035
R18	0683-1035	1		1	RESISTOR 10K 5% .25W FC TC=+400/+700	01121	CB1035
R19	0698-3042	0		1	RESISTOR 2.07K 1% .125W F TC=+100	24546	CA-1/8-T0-2671-F
R20	0683-2235	3		3	RESISTOR 2.2K 5% .25W FC TC=+400/+700	01121	CB2235
R21	0683-2235	5		4	RESISTOR 22K 5% .25W FC TC=+400/+800	01121	CB2235
R22	0757-0442	0		0	RESISTOR 10K 1% .125W F TC=+100	24546	CA-1/8-T0-1002-F
R23	0757-0447	0		4	RESISTOR 10.2K 1% .125W F TC=+100	24546	CA-1/8-T0-1022-F
R24	0683-4725	2		10	RESISTOR 4.7K 5% .25W FC TC=+400/+700	01121	CB4725
R25	0683-1045	3		6	RESISTOR 100K 5% .25W FC TC=+400/+800	01121	CB1045
R26	0683-2235	5		5	RESISTOR 22K 5% .25W FC TC=+400/+800	01121	CB2235
R27	0683-4725	2		2	RESISTOR 4.7K 5% .25W FC TC=+400/+700	01121	CB4725
R28	0757-0442	0		0	RESISTOR 10K 1% .125W F TC=+100	24546	CA-1/8-T0-1002-F
R29	0698-3150	0		2	RESISTOR 10K 1% .125W F TC=+100	24546	CA-1/8-T0-1002-F
R30	0683-4705	0		3	RESISTOR 23.7K 1% .125W F TC=+100	24546	CA-1/8-T0-2372-F
R31	0683-4715	0		2	RESISTOR 47 5% .25W FC TC=+400/+500	01121	CB4715
R32	0683-4725	2		2	RESISTOR 470 5% .25W FC TC=+400/+600	01121	CB4725
R33	0683-1045	3		3	RESISTOR 100K 5% .25W FC TC=+400/+800	01121	CB1045
R34	0683-2235	5		5	RESISTOR 22K 5% .25W FC TC=+400/+800	01121	CB2235
R35	0757-0442	0		0	RESISTOR 10K 1% .125W F TC=+100	24546	CA-1/8-T0-1002-F
R36	0683-4725	2		2	RESISTOR 4.7K 5% .25W FC TC=+400/+700	01121	CB4725
R37	0757-0442	0		0	RESISTOR 10K 1% .125W F TC=+100	24546	CA-1/8-T0-1002-F
R38	0011-3526	2		3	RESISTOR .010 3% 5W PW TC=+200	28480	0011-3526
R39	0698-3609	0		0	RESISTOR 22 5% 2W MO TC=+200	27167	FP42-2-T00-2200-J
R40	0698-3609	0		0	RESISTOR 22 5% 2W MO TC=+200	27167	FP42-2-T00-2200-J
R41	0683-4725	2		2	RESISTOR 4.7K 5% .25W FC TC=+400/+700	01121	CB4725

MANUFACTURERS CODE LIST

AS OF 10/09/79

MFR NO.	MANUFACTURER NAME	ADDRESS	ZIP CODE
00000	ANY SATISFACTORY SUPPLIER	HARRISBURG PA	17105
00779	AMP INC	MILWAUKEE WI	53204
01121	ALLEN-BRADLEY CO	DALLAS TX	75222
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	BOYERVILLE NJ	08876
01928	RCA CORP SOLID STATE DIV	PHOENIX AZ	85002
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	BIRMINGHAM MA	01503
11961	SEMICON INC	WATERLOO MA	02172
12969	UNITRODE CORP	DALLAS TX	75234
13103	THERMALLOY CO	MICHAELVILLE NY	11912
14936	GENERAL INSTR CORP SEMICON PROD GP	ANAPHEIM CA	92606
15054	RODAN INDUSTRIES INC	RALEIGH NC	27604
16209	CORNING GL WK ELEC CMPNT DIV	BRADFORD MA	10701
24546	CORNING GLASS WORKS (BRADFORD)	SANTA CLARA CA	95051
27014	NATIONAL SEMICONDUCTOR CORP	WILMINGTON NC	28401
27167	CORNING GLASS WORKS (WILMINGTON)	GARLAND TX	75041
27777	VARO SEMICONDUCTOR INC	PALO ALTO CA	94304
29480	HEWLETT-PACKARD CO CORPORATE HQ	SANTA CLARA CA	95051
31471	AMERICAN MICRO SYSTEMS INC	CUPERTINO CA	95014
32293	INTERFIL INC	CARROLLTON TX	75006
50088	MOBTEK CORP	MONTH ADAMS MA	01247
56289	SPRAGUE ELECTRIC CO		

Replaceable Parts

Reference Designation	HP Part Number	C D	Qty	Description	Mfr Code	Mfr Part Number
	1205-0200	4	2	HEAT SINK TO-3-CS	20400	1205-0200
	1205-0340	7	1	HEAT SINK SGL PLTFC-PWR-CS	13103	00250-TT
	1390-0100	3	4	PASTENER-SNAP-IN GRM PANEL THKNS	20400	1390-0100
	1390-0201	7	4	PASTENER-SNAP-IN PLGR PANEL THKNS	20400	1390-0201
	1400-0200	0	1	CABLE TIE .002-.025-DIA .091-ND NYL	20400	1400-0200
	2110-0551	3	3	FUSEHOLDER-CLIP TYPE 15A 250 V .250-FUSE	20400	2110-0551
	2190-0003	0	1	WASHER-LK MLC L NO. 6 .115-IN-ID	20400	2190-0003
	2190-0007	2	15	WASHER-LK INTL T NO. 6 .141-IN-ID	20400	2190-0007
	2190-0011	0	0	WASHER-LK INTL T NO. 10 .195-IN-ID	20400	2190-0011
	2000-0120	0	0	SCREW-MACH 10-32 .312-IN-LS PAN-ND-POZI	00000	ORDER BY DESCRIPTION
	3050-0247	7	1	WASHER-PL NH NO. 6 .141-IN-ID .375-IN-OD	20400	3050-0247
	5001-2000	0	1	HEAT SINK	20400	5001-2000
	02620-20001	3	1	HEAT SINK	20400	02620-20001
	02620-40007	1	1	COVER, SCREW	20400	02620-40007