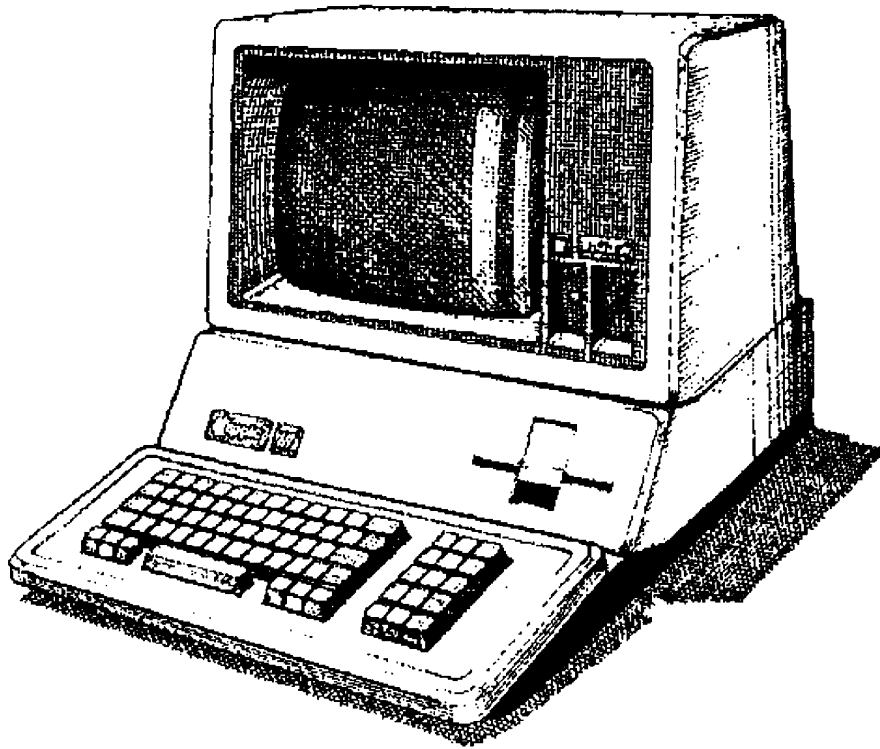




Apple /// Computer Information

Apple /// Service Reference Manual



Section I of II • Theory of Operation

Chapter 9 • Power Supply

Written by Apple Computer • 1982



THE APPLE /// POWER SUPPLY

The Apple /// power supply converts power from the AC line to DC. This is a constant voltage power supply. This means:

1. The output voltage is maintained constant regardless of changes in the load, line, or temperature.
2. The Apple /// power supply is a free running flyback type, off line switching power supply.
 - It can accept either 115VAC or 230VAC (jumper selectable) and delivers 4 regulated DC outputs at a total of 55 watts.
 - It supplies +5, -5, +11.8, and -12VDC.
 - It is called a flyback type power supply because energy is transferred from the primary of the transformer to the secondary when the switching transistor switches off (during flyback).

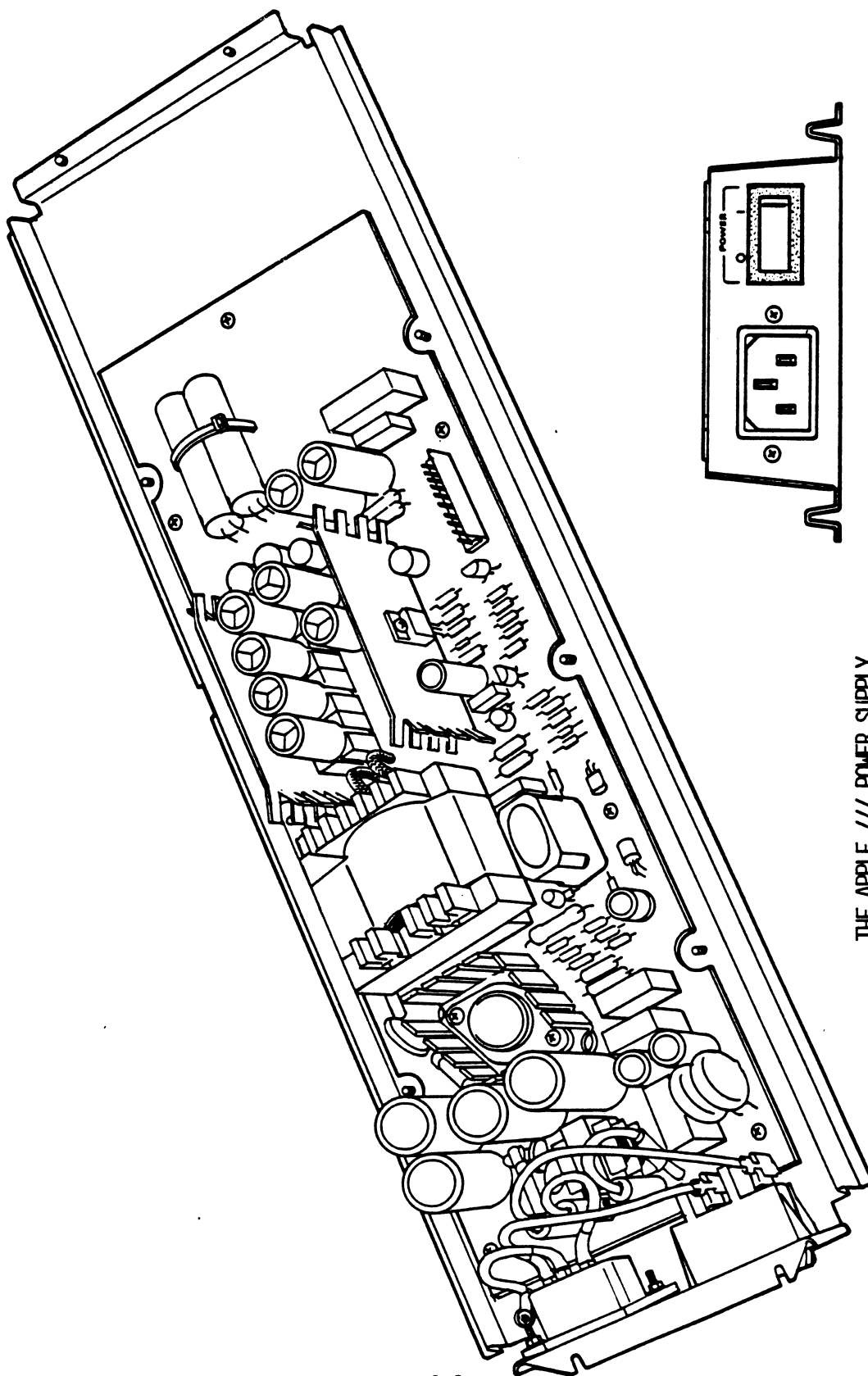
The following paragraphs will describe the switching power supply in more detail.

THE BASIC SWITCHING POWER SUPPLY

The regulating element of the switching power supply consists of a transistor that acts as a rapidly opened and closed switch. The AC input is rectified to unregulated DC, then "chopped" by the switching element components at a fast rate, approximately 25kHz. The resultant is transformer-coupled to an output network which provides the final rectification and filtering. Regulation is accomplished through control circuits that vary the on-off periods (duty cycles) of the switching components.

Advantages

1. Greater Efficiency
 - Lower power is dissipated because of the on/off role of the regulator. The switching transistors dissipate very little power when either saturated (on) or cutoff (off). With less wasted power, the switching power supply runs at cooler temperatures and costs less to operate.
2. Size and Weight
 - Because components such as capacitors, transformers, and inductors operate at high switching rates they can be smaller and weigh less than those that operate at power line frequencies.
3. Operating Conditions
 - The switching power supply can operate under low AC conditions and can sustain (holdup) its output if input power is momen-



THE APPLE /// POWER SUPPLY
PARTS LAYOUT

9.2



tarily lost. This is because the AC input is rectified and the filter capacitors charge to peak voltages on the AC line.

Disadvantages

1. Transient Recovery Time

- The dynamic loading regulation is slower than that of the series regulated supply. The recovery is limited mostly by the inductance of the output filter network.

2. EMI (Electro-Magnetic Interference)

- This is a natural byproduct of this type of power supply. This EMI can be conducted to the load (resulting in higher output ripple and noise), and it can be conducted back into the AC line. (Now you know where that stuff on TV came from).
- Apple designed this power supply with filter networks and shielding to greatly reduce EMI.

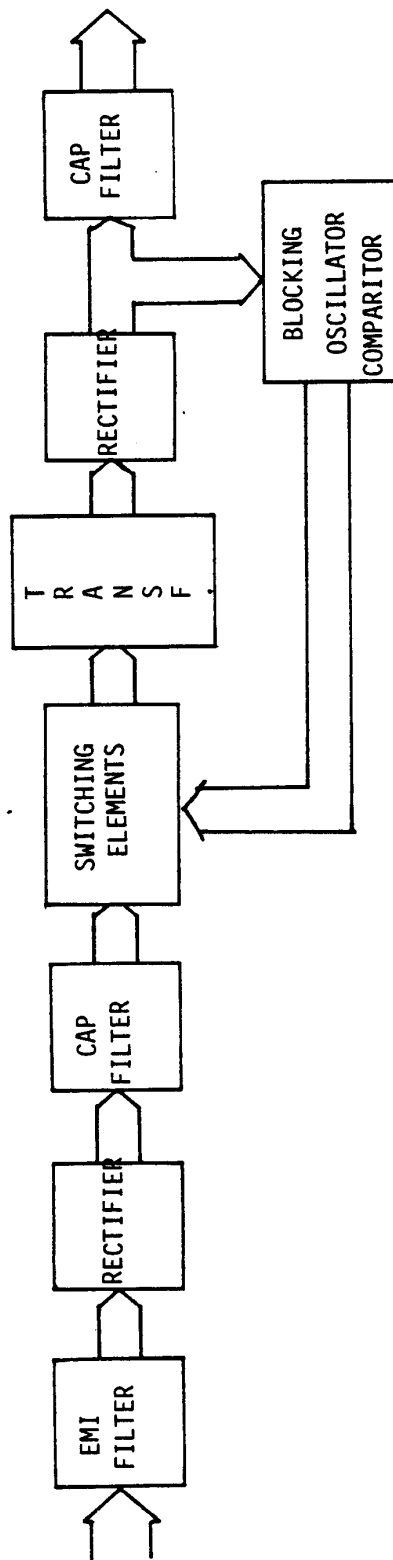
HOW IT WORKS!

Regulation is accomplished by a switching transistor Q2 operating under control of a feedback network. The feedback network, consisting of a voltage comparator and blocking oscillator, controls the duty cycle of the oscillator.

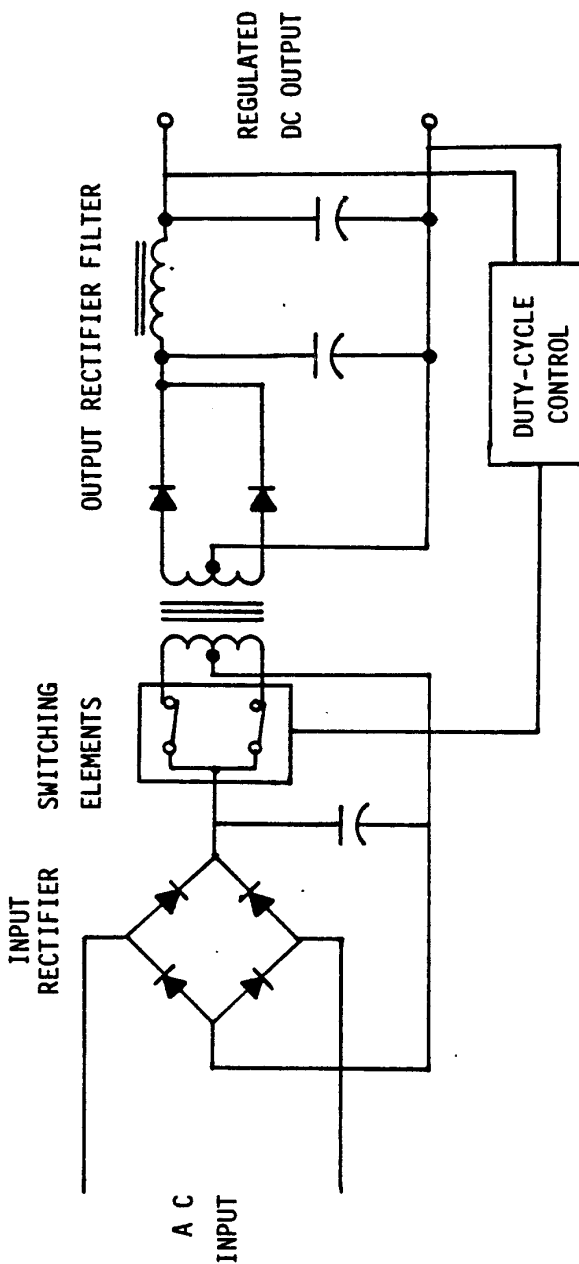
The energy is transferred from the primary to the secondary of the transformer and delivered to the output rectifier/filter. Here the waveform is rectified and averaged to provide a DC output level that is proportional to the duty cycle of the waveform.

Referring to the block diagram, Figure x.x below, note that:

- o The AC is passed through an EMI filter and then rectified to provide approximately 300 VDC across the capacitive input filters (C6, C7, C8, C9 of the schematic diagram). This voltage is applied to the primary of the transformer (T2) by the switching elements (turning on power transistor Q2). A linear current ramp is developed by the primary inductance of the transformer.
- o When the switching elements are turned off, the energy stored in the transformer is transferred to a second set of rectifiers through a capacitive filter network to provide filtering of the output.
- o The +5 volt output of the final rectifier network is compared to a reference voltage, and the error is fed back to a blocking oscillator.
- o The blocking oscillator basically changes the frequency depending on the output voltage. This in turn changes the repetition rate of the switching elements, which changes the energy transfer through the transformer and voltage output. This is how regulation is accom-



9.4



9.5



plished.

- o If the output voltage should change in such a way that the blocking oscillator goes into saturation, the output is essentially cut off.

DETAILED HARDWARE DESCRIPTION [Refer to Schematic]

A THERMISTOR, R1, is used to limit AC input surge current by its negative temperature coefficient of resistance. When cold, during turn on, R1 has a high resistance; after it heats up, R1 has a low resistance.

VDR1 is a varistor and is used as a transient suppressor. It keeps voltage spikes that result from power supply switching from affecting the performance of the power supply. It basically provides AC line surge current protection at turn on.

THE AC LINE SELECTABLE JUMPER, when connected to 220V position, causes the power supply to act as a conventional full wave rectifier. For 120V AC inputs the input circuitry becomes a voltage doubler.

THE EMI FILTER made up of T1, L1, L2, and C1, helps prevent high frequency RFI spikes from being conducted to the load or back into the AC line.

DB1 is a diode rectifier bridge.

THE SWITCHING ELEMENT consists of the circuitry associated with Q2 and Q1. You may recall that the linear current ramp, developed in the primary of the transformer when Q2 is turned on, is transferred to the secondary when Q2 is turned off.

The turn on of Q2 is accomplished by R2 for starting, and thereafter by the feedback winding in T2 driven by R4 and C10. This winding initiates turn on during the ringdown following the flyback.

If a sufficient voltage is developed across R9, Q1 will be forward bias. This would occur if by chance one of the output voltages were shorted. In that case, the oscillator would stop and shut off all the outputs, pause for 1/2 second, and attempt to restart.

THE OUTPUT RECTIFIER DIODES, D7 through D12, provide rectification, but also protect internal components against reverse currents that could be injected into supply by an active load.

IC1 helps accomplish regulation by comparing the output voltage against its own internal reference and delivering a voltage level to the base of Q3.

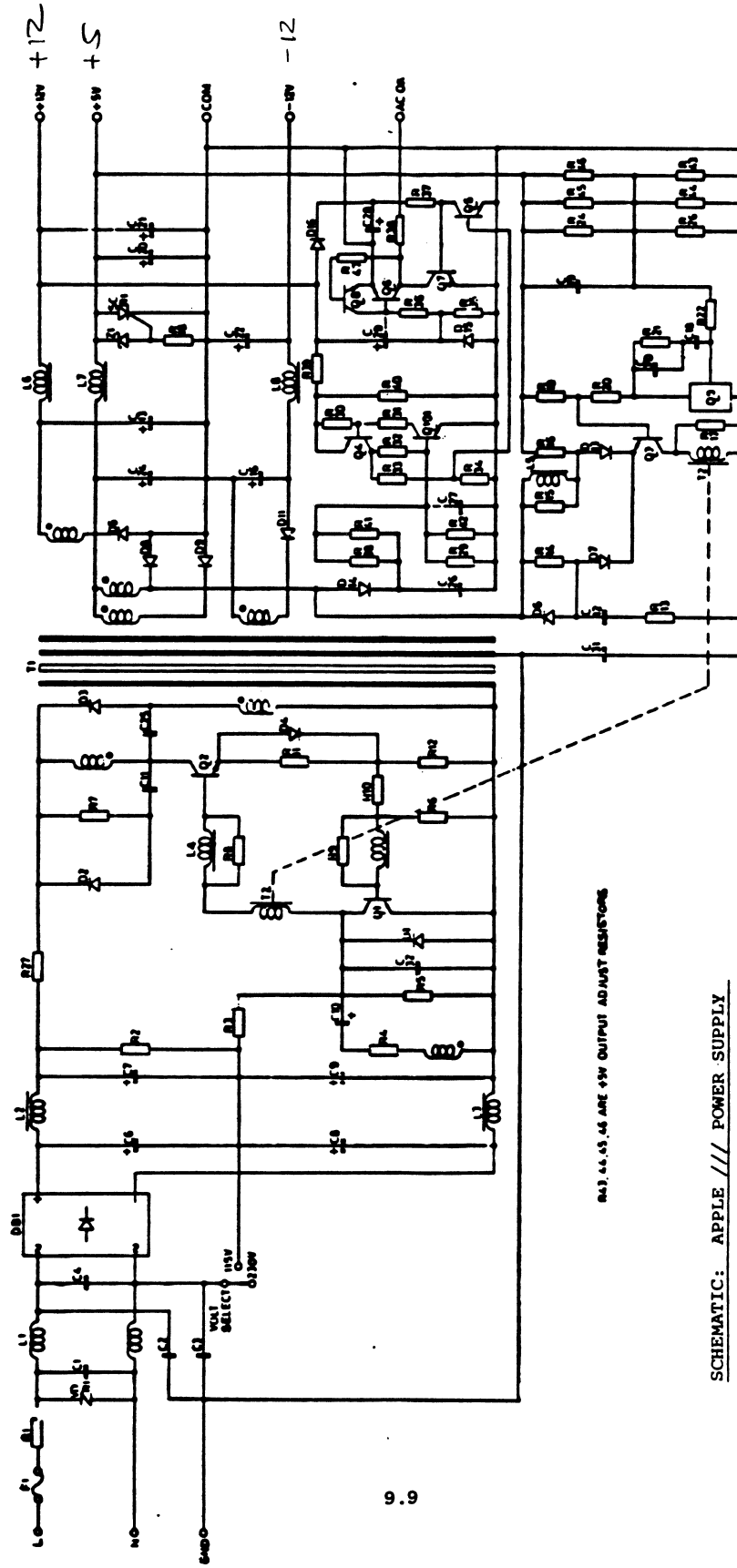
The emitter of Q3 is driven by a positive going ramp created by the inductive resistance associated with R14 while Q2 is on. When this voltage is sufficient to forward bias the emitter-base junction of Q3, conduction of Q2 is terminated.

You can now see that the operating frequency varies with the line and load.

OVERVOLTAGE PROTECTION is accomplished by sensing the +12V level via the re-



istor voltage divider of R17 and R18, referenced to the zener voltage on Z1. When the +12V output rises above tolerance, Q4 is turned on, which in turn triggers SCR1. SCR1 then clamps the +12V to ground, causing the power supply to fold back.



9.9

RA3, RA4, RA5, RA6 ARE 15W OUTPUT ADJUST RESISTORS

SCHEMATIC: APPLE /// POWER SUPPLY

APPLE III POWER SUPPLY

REF	DESCRIPTION	QTY	PART NUMBER
	AC Input Socket		149-00200020
	Connector Housing 1 CCT	1	138-00000170
	Crimp Terminal	1	403-02200510
	Double Side Tape Width=3x4mm	20	027-01400010
	Faston Tab	1	403-02200700
	Heatsink	1	398-00200060
	Insulator 298. 45X88.9MM	1	183-00101410
	Nut M3 P=0.5 MS/NP	2	394-00400011
	On/Off Switch	1	278-01100010
	Pan	1	403-01101810
	PHL Pan M.C Screw M#x12 P=0.5 BS/NP	2	391-20204141
	PHL Pan M.C Screw M3X8 P=0.5 BS/NP	3	391-20204061
	PHL Pan M/C Screw M3X8 P=0.5 BS/NP	1	391-20204021
	PVC Coating CU Wire 100MM UL1015	1	356-12200571
	PVC Coating CU Wire 80MM UL1015	1	357-11800545
	PVC Coating CU Wire 95MM UL1015	1	356-12200566
	Rectifier RG3B	3	226-10700011
	Resistor, 68K \pm 5% 1/4W, Carbon Film	2	240-68306022
	Resistor, 82K \pm 5% 1/4W, Carbon Film	2	240-82306022
	SCR C122u	1	227-13000010
	Solder Bar	1	366-00130010
	Solder Bar 60/40	0	366-00130010
	Spring Washer M3 BS/NP	10	392-00800031
	Standoff M3	8	393-00200100
BRI	Bridge Rectifier KBP10		226-30500010
C01	Cap, 0.22uf, 250VAC, Metallized Paper	1	068-22400010
C02	Cap 0.1uf, 250VAC, Metallized Paper	1	068-10400010
C03	Cap, 4700pf, 400 VAC, Ceramic	2	055-47220001
C04	Cap, 4700pf, 400 VAC, Ceramic	2	055-47220001
C05	Cap, 0.1uf, 400 V, Polyester	1	058-10400100
C06	Cap, 100uf, 250V, Electrolytic	4	057-101201170
C07	Cap, 100uf, 250 V, Electrolytic	4	057-101201170
C08	Cap, 100uf, 250v, Electrolytic		057-10120170
C09	Cap, 100uf, 250V, Electrolytic	4	057-101201170
C10	Cap, 100uf, 250V, Electrolytic	1	057-22120080
C11	Cap, 0.001uf, 3KV, Ceramic		055-10261328
C12	Cap, 22uf, 100V, Polyester	2	058-22400120
C13	Cap, 1000uf, 10V, Electrolytic	6	057-10220020
C14	Cap, 1000uf, 10V, Electrolytic	6	057-10220020
C15	Cap, 1000uf, 10V, Electrolytic	6	057-10220020
C16	Cap, 1000uf, 10V, Electrolytic	6	057-10220020
C17	Cap, 330uf, 16V, Electrolytic		057-33120080
C18	Cap, 220uf, 10V, Electrolytic	1	057-22120060
C19	Cap, 0.22uf, 100V, Polyester	1	058-22300080
C20	Cap, 1000uf, 10V, Electrolytic		057-10220020
C21	Cap, 0.22uf, 100V, Polyester		058-22400120
C22	Cap, 1000uf, 10V, Electrolytic		057-10220020
C23	Cap, 330uf, 16V, Electrolytic	3	057-33120080
C24	Cap, 680uf, 16V, Electrolytic	1	057-68120010
C25	Cap, 330uf, 16V, Electrolytic	3	057-33120080
C26	Cap, 0.1/1KV, Ceramic	1	055-10360925
D01	Diode, Rectifier, RGP10A	1	226-10400050
D02	Diode, Rectifier, RGP10M	2	226-10400100
D03	Diode, Rectifier, RGP10M	2	226-10400100

APPLE III POWER SUPPLY

REF	DESCRIPTION	QTY	PART NUMBER
D04	Diode, Rectifier, 1N4001GP	1	226-10400080
D05	Diode, Silicon, 1N5282	3	212-10700200
D06	Diode, Silicon, 1N5282	3	212-10700200
D07	Diode, Rectifier/Scr Assembly		853-00700010
D08	Diode, Rectifier assembly		853-00200140
D09	Diode, Rectifier Assembly		853-00200140
D10	Rectifier Assembly		853-00200140
D11	Schottky Diode S3SC3M		212-31100030
D12	Rectifier RG3B	1	226-10700010
D13	Diode, Silicon, 1N5282	3	212-10700200
F1	Fuse 2.75A 125V	1	084-00200040
IC1	Integrated Circuit, Regulator, TL431CP	1	211-10800070
J1	Jumper Wire	4	358-80810011
J2	Jumper Wire	4	358-80810011
J3	Jumper Wire	4	358-80810011
J4	Jumper Wire	40	358-80800001
L1	Choke	2	852-20100350
L2	Choke	2	852-20100350
L3	Base Choke	1	328-00100030
L4	Choke 1.5mH	1	328-00100010
L5	Choke Coil Assembly	1	852-20100010
L6	Choke Coil	1	852-10100370
L7	Choke Coil	1	328-00100060
L8	Choke Coil	1	328-00100060
Q1	Transistor SD467	1	209-11700463
Q2	Transistor 2SC1358	1	209-10200010
Q3	Transistor SB561	2	210-11700353
Q4	Transistor SB561	2	210-11700353
R01	Thermistor, 4R @25 C \pm 10% 6R @ 25 C \pm 20%	1	258-40970015
R02	Resistor, 150K \pm 5% 1/2W	2	240-15406033
R03	Resistor, 150K \pm 5% 1/2W		240-15406033
R04	Resistor, \pm 5% 47R 2W, Metal Oxide	1	248-47006063
R05	Resistor, \pm 5% 1/4W 1.2K	1	240-12206022
R06	Resistor, 5.6R \pm 5% 1/4W	1	240-56906022
R07	Resistor, \pm 5% 56R 1/4W, Carbon film		240-56006022
R08	Resistor, \pm 5% 120R 2W	1	248-12106063
R09	Resistor, \pm 5% 1/4W 15R	2	240-15006022
R10	Resistor, \pm 5% 1/4W 10R, Carbon Film	1	240-10006022
R12	Resistor, 0.47R, Metal Film	1	247-04786054
R13	Resistor, -5% 1/4W 39R, Carbon Film	1	240-39006022
R14	Resistor, \pm 5% 270R 1/4W	2	240-27106033
R15	Resistor, \pm 5% 270R 1/4W, Carbon Film		240-27106033
R16	Resistor, 8.2 \pm 5% 1/4W, Carbon Film	1	240-82906022
R17	Resistor, \pm 5% 680R 1/4W	1	240-68106022
R18	Resistor, \pm 5% 1.8K, Carbon Film	1	240-18206022
	Resistor, \pm 5% 2.2K, Carbon Film	1	240-22206022
	Resistor, \pm 5% 2.7K 1/4W, Carbon Film	1	240-27206022
R19	Resistor, \pm 5% 560R 1/4W, Carbon Film	1	240-56106022
R20	Resistor, 22R 1/4W \pm 5%, Carbon film	1	240-22006022
R21	Resistor, 100R \pm 5% 1/4W, Carbon Film	1	240-10106022
R22	Resistor, 56R \pm 5% 1/4W, Carbon Film	3	240-56006022
R23	Resistor, 56R \pm 5% 1/4W, Carbon film		240-56006022
R243	Resistor, 12K \pm 5% 1/4W, Carbon Film	1	240-12306022
R25	Resistor, \pm 5% 1/4W 470R, Carbon Film		240-47106022

APPLE III POWER SUPPLY

REF	DESCRIPTION	QTY	PART NUMBER
R26	Resistor, +-2% 2.7K 1/4W, Metal Film	2	247-2701502
R27	Resistor, +-2% 2.7K 1/4W, Metal Film		247-27015022
R28	Resistor, 100K +-5% 1/4W, Carbon Film	2	240-10406022
R29	Resistor, 100K +-2% 1/4W, Carbon Film		240-10406022
R30	Resistor, -5% 56R 1W, Metal Oxide Filmm	1	248-56006052
R31	Resistor, +-5% 220R 1W, Metal Oxide Film	1	248-22106052
R32	Resistor, 1R 1w, Metal film	1	247-10086054
T1	Common Mode Choke Assembly	1	852-20200010
T2	Power Transformer assembly	1	852-10200760
T3	Control Transformer Assembly	1	852-10200680
VDRL	Varistor 260VAC	1	256-26100014
Z1	Zener Diode 9.6 to 10.V @ 1mA	1	222-98085002

