Z-100 LifeLine
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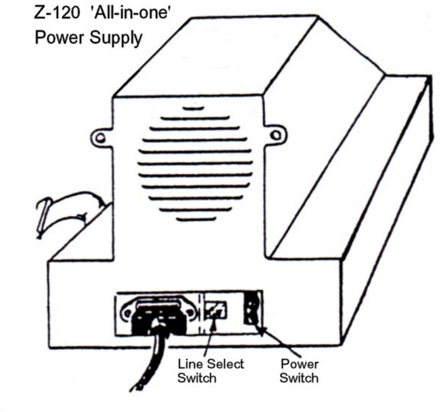

Z-100 Power Supply

by Steven W. Vagts
Editor, 'Z-100 LifeLine'

Z-110/Z-120 Power Supply

INTRODUCTION

The Z-100 Power Supply is an off-line, voltage-fed, half-bridge, switch-mode power supply, commonly referred to as a Switching Power Supply. The power supply comes in two externally different designs, one for the Low Profile Z-110 and one for the All-in-One Z-120 series computer. Except for the exterior difference in appearance, and the additional +12 Vdc supply for the All-in-One's monochrome monitor, their interiors are identical.

In the switching type power supply, the AC line voltage is first rectified into direct current, then this direct current is switched on and off at a very high frequency, chopping this DC into a quasi-square wave. This square wave drives the primary of an inverter transformer. The secondary currents are converted to low voltage DC by using rectifiers and low-pass filters.

SPECIFICATIONS

AC Input Voltage: (switch selectable)	100-130 VAC, 60 Hz; 200-260 VAC, 50 Hz;
Temperature Range:	10-50 degrees C.
Hold Up Time:	16 ms at full load.
Current Limiting:	130% of max output shuts down power supply.
Maximum Turn-on Surge:	60 amperes for 1/2 cycle.
Overvoltage Protection:	130% overvoltage on +5 volt line shuts down power supply.
DC Outputs:	+5 Vdc +3% at 12 amperes max. Including ripple, 2 amperes min. Ripple: 100 mV peak-to-peak max.
	+12 Vdc +5% at 5.2 amps max, with +5 Vdc load at 6 amps. Including ripple, 0.4 amperes min. Ripple: 120 mV peak-to-peak max.
	+8 Vdc, +10%, -5% at 8 amperes max. Including ripple, 150 mA min. Ripple: 120 mV peak-to-peak max.
	+16 Vdc, +20%, -10% at 1 ampere max. Including ripple, 5 mA min. Ripple: 150 mV peak-to-peak max.
	-16 VDC, +20%, -10% at 1 amp max at 5 mA min. Ripple: 120 mVp-p max.
All-In-One Version Only: (Additional)	+12 VDC +5% output at 1.5 amps max. Ripple: 50 mVp-p max.

REFERENCES

Zenith Z-100 Technical Manual, Chap. 8
Zenith Training School Manual
"Radio Electronics", December 1985 Issue
Switching Power Supplies

THEORY OF OPERATION

EMI FILTER

All power entering the power supply passes through an EMI filter, composed of C1, C2, C3, C4 and L1. Its main function is to reduce conducted emissions emanating from the power supply to a point where it complies with the regulatory agencies.
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Following the filter is the surge protector, MOV1. Its function is to attenuate high voltage transients from entering the power supply.

AC POWER MAINS TO DC CONVERSION

CR1, RT1, RT2, C5, C6 and R1-R4 form the AC-to-DC conversion circuit.

When the 115/230 switch (S2) is closed (115v operation), this circuit is configured in a voltage doubler mode. Each half-power line cycle, C5 and C6 are alternately charged to 1.414 times the rms line voltage. Since the load is across the two capacitors, the voltage is 2 times the voltage across each capacitor. The two lower diodes of the bridge, CR1, are not used in this mode.

When the 115/230 switch (S2) is open (230v operation), the AC-to-DC conversion circuit is configured in a full-wave bridge mode. Now C5 and C6 are charged in series each half cycle. The load "sees" the same DC voltage regardless of the power line voltage selected.

Thermistors RT1 and RT2 limit power line inrush when the supply is first turned on. Resistors R1-R4 discharge C5 and C6 when the supply is turned off (UL requirement).

DC TO QUASI-SQUARE WAVE CONVERSION

Transistors Q1 and Q2 form two active switches that "chop" the DC. They operate 180 degrees out of phase. They are driven through driver/ isolation transformer, T1. Diodes CR2 - CR5 and capacitors C11 & C12 form two turn-off enhancement circuits.

When Q1 or Q2 is forward biased, C11 or C12, respectively, charges up to approximately 1.2 volts. When the drive circuit signals either transistor to turn off, it does this by effectively shorting out the primary of transformer T1. Since the secondaries are not effectively shorted, the last charged capacitor is placed across the emitter-base junction of the forward biased transistor. Therefore, at the first instant, the emitter-base junction is reverse biased to approximated 1.2 volts. This supplies not only sufficient base current, IB2, but keeps the transistors reverse biased to prevent false turn on.

Diodes CR6 and CR7 are "catch" diodes that return any inductive energy to the input capacitors, C5 and C6. They also protect Q1 and Q2 from reverse breakdown. R5 and C13 for a "snubber" network. This circuit limits the "ringing" due to leakage inductance in T3 and T4.

The base drive scheme is a proportional type. The three-turn winding of T1 has the entire primary current of inverter transformers, T3 and T4, circulating through it. As the output load is increased, so does the amount of base drive to Q1 and Q2. This provides optimum drive under all load conditions.

Transistors Q5 through Q8 form a "push-pull" inverter drive circuit. Transistors Q5 and Q7 provide the turn-on signal to its respective inverter transistor. Transistors Q6 and Q8 provide the turn-off signal to its respective inverter transistor. Diodes CR36 and CR38 allow the current to commutate during turn off. Transistors Q3 and Q4 act as logic inverters between the switching regulator IC1 and the inverter drive circuit.

INTEGRATED SWITCHING REGULATOR - OPERATION

Regulated DC power supplies are governed by feedback mechanisms that sense changes in the output voltage and generate control signals to compensate for those changes. In a linear regulator, the transistor providing control over the circuit operates in the linear region, that is, the linear portion of the transistor's power curve.

An error amplifier compared the circuit's output voltage with an internal reference voltage and the resultant differential was fed back to the control transistor. The current flow through the transistor continued as long as the input voltage exceeded the minimum necessary to keep the regulator working.

In a switching power supply, however, the addition of control logic and an oscillator allow control of frequency, duty cycle, or both, which, in turn, controls the output voltage. The transistor is forced to switch rapidly between saturation and cutoff, remaining in the linear region for only the short period of time required to perform the switching action. This action had much greater efficiency than the linear regulator.

One of the most popular switching voltage regulator ICs was National Semiconductor's LM3524, the heart of the Z-100's power supply, IC1.

The LM3524 has a built-in Pulse Width Modulator (PWM), a circuit that varies the duty cycle of a pulse train while keeping its frequency constant. The PWM is used to vary the "on" time of the series-pass elements.

Note: Figure 1. is a Texas Instruments LM3524d. The LM3524D family is an improved version of the industry standard LM3524. It has improved specifications and additional features yet is pin for pin compatible with existing 3524 families. New features reduce the need for additional external circuitry often required in the original version (Please let me know if you notice a difference - SWV).

Pin 16 is an internal reference of approximately 5 volts. The inputs to the error amplifier are pins 1 and 2. The error amplifier is a transconductance differential-input type with a nominal gain of about 80 dB; that gain may be set either by feedback or output loading, and loading does not necessarily have to be purely resistive.

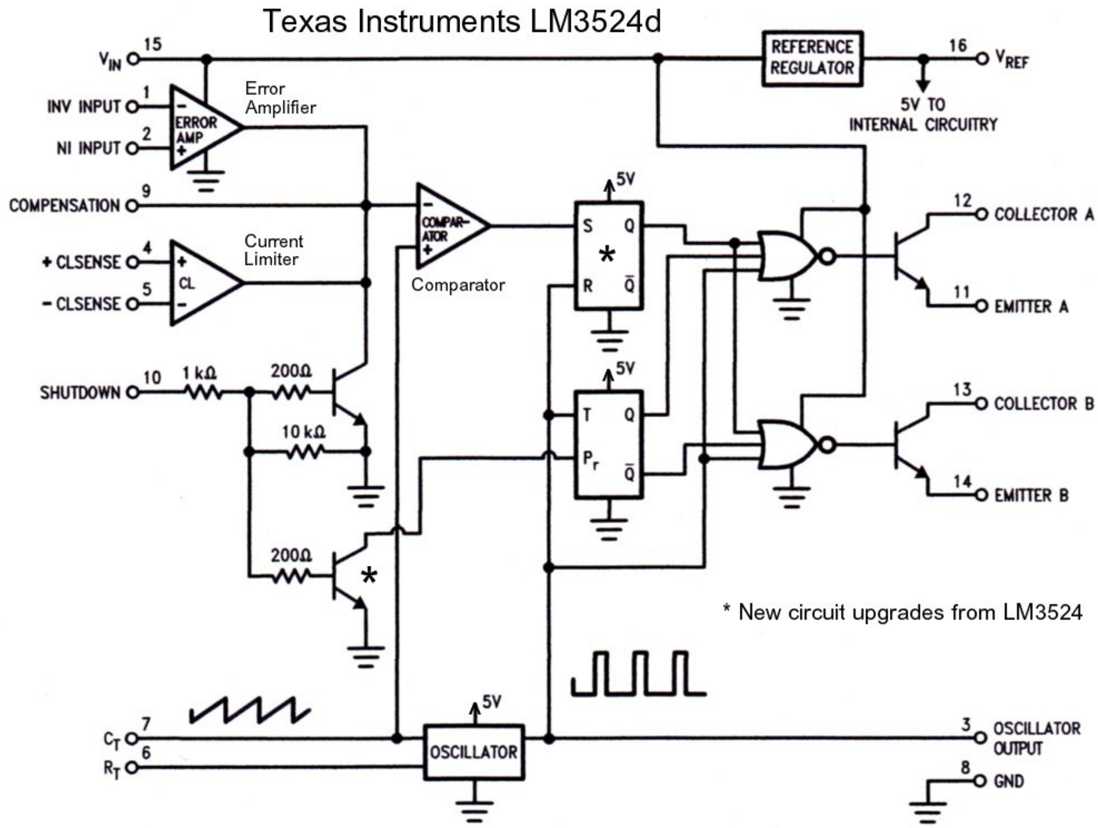


Figure 1. Texas Instruments LM3524d

The output of the amplifier, which is also the input to the PWM, has an impedance of about 5 megohms, and that enables it to be overridden by a DC voltage, thereby forcing a desired duty cycle to appear at the output. Normally, the amplifier's inputs have a common-mode range of 1.8 to 3.4 volts, and the IC's on-chip regulator is typically used to bias the inputs to a value within that range.

In the Z-100, approximately 2.5 volts is applied to pin 2 by dividing down the reference through resistors R21, R22, and R23. C29 is a noise decoupling capacitor. The voltage from the +5 volt source is divided down by R17 and R18 to approximately 2.5 volts to be applied to pin 1. Pin 9 is the output of the error amplifier. Frequency compensation, for proper rool off and phase margin is provided by C26, C43, and R19.

Current limiting in the LM3524, a feature not used in the Z-100, is performed by decreasing the width of its output pulses. The output duty cycle drops to about 25% when a potential of 200 mV is present between terminals 4 and 5; 210 mV will reduce the duty cycle to 0%. The total potential difference between those two terminals must not exceed -0.7 to +1.0 volt.

In the Z-100, both pins 4 and 5 are tied to ground.

The frequency of the IC's internal oscillator is determined by the combination of external resistor R28 and external capacitor C30. In a nomograph, resistance values between 1.8K and 100K ohms and capacitance values between 0.001 uF to 0.1 uF would cause an oscillation period between 3 and 1000 microseconds (us).

In the Z-100, R28 = 2.7K ohms and C30 = .0047 uF, giving a period of oscillation of about 15 microseconds (us).

The output of the oscillator drives a flip-flop that in turn drives two NOR gates. They are driven out of phase by the flip-flop's Q and Q outputs. The IC's output is disabled by the comparator whenever its output goes high. That happens whenever the error amplifier determines that the internal reference voltage equals or exceeds the sampled portion of the output voltage. That also happens whenever the current-limit amplifier senses an overload condition.

The output stage of the LM3524 consists of two NPN transistors, driven 180 degrees out of phase with each other by the flip-flop. Each transistor is capable of supplying a current of 100 mA to pins 12 and 13.

To prevent cross conduction of inverter transistors Q1 and Q2, at any time, a "dead time" limiting circuit is incorporated, using R24, R25 and CR26 at pin 9 of IC1. R24 and R25 form a 2.5 volt voltage divider off the +5 volt internal reference. If the output of the error amplifier ever attempts to slew above this 2.5 volt level, CR26 is forward biased, clamping the output. As a result, the maximum duty ratio attainable is approximately 90%.

Diodes CR24 and CR25, R20 and C27 form a slow start circuit, also at pin 9 of IC1. This circuit prevents the output from the supply from overshooting on turn-on. The circuit also limits the amount of current the inverter transistors must sustain during turn-on.

At turn-on, C27 is at zero volts. Diode CR25 clamps the output of the error amplifier to one diode drop. Through IC1 logic, this forces Q3, Q4, Q6, and Q8 to conduct. This prevents Q1 or Q2 from switching. Now C27 is charged through R20, allowing the output of the error amplifier to rise.

Eventually, IC1 allows a minimal on-time to occur on one of the inverter transistors. A short time later, the other inverter transistor conducts for the same duration. Now, the outputs begin to rise. This process of "walking" up the outputs continues until the inputs of the error amplifier are equal.

At this point, the "loop" is closed, capacitor C27 continues to charge to the internal reference voltage, and CR25 is reverse biased. Diode CR24 resets the slow-start capacitor, C27, when the supply is turned off.

OUTPUT STAGES

+5 VOLT OUTPUT: Diode CR9 comprises a full-wave Schottky rectifier that changes a secondary quasi-square wave to a positive polarity square wave for the +5 volt output. L2 and C14 form a low-pass filter to convert the square wave to DC. R6 is a discharge resistor and C21 is a high frequency by-pass capacitor.

+12 VOLT QUASI-REGULATED OUTPUT: Diode CR10 comprises a full-wave rectifier that changes a secondary quasi-square wave to a positive polarity square wave for the +12 volt output. L3 and C17 comprise a low-pass filter to convert the square wave to DC. R76 is a discharge resistor and C22 is a high frequency by-pass capacitor. R56, R57, C39, and C40 are two snubber networks to dampen "ringing" due to the leakage inductance of T3.

+8 VOLT OUTPUT: Diode CR8 comprises a full-wave Schottky rectifier that changes a secondary quasi-square wave to a positive polarity square wave for the +8 volt output. L6 and C16 form a low pass filter to convert the square wave to DC. R7 is a discharge resistor and C20 is a high frequency by-pass capacitor.

+16 VOLT OUTPUT: Diodes CR12 and CR14 comprise a full wave rectifier that changes a secondary quasi-square wave to a positive polarity square wave for the +16 volt output. L4 and C18 form a low-pass filter to convert the square wave to DC. R77 is a discharge resistor and C23 is a high frequency by-pass capacitor. This output is also used for "boot strapping" the bias supply through CR33.

The purpose of this is twofold:

1) To maintain the bias voltage once the power to the supply is turned off for output carryover.

2) To allow the use of a small bias transformer, T5, which is used only on start up.

Another use of the +16 volt output is the power source for the +12 volt regulated output. The operation of this regulator is described in the +8 Volt Output section.

Finally, the DC fan for the supply is run off this line. The earlier models used RT3, as the schematic shows, so the fan would run faster as the supply started to overheat.

In later models, however, RT3 was replaced by an R61 assembly consisting of 2 56 ohm, 2w resistors (or a 30 ohm, 5w resistor) and a 5 volt (#279-19) zener diode in parallel. Fan speed no longer changes.

+12 VOLT REGULATOR OPERATION: The +12 volt linear regulator is made up of discrete transistors Q9 thru Q11. The +5 volt output, used as a reference, is applied to the emitter of Q9. Since, at the first instant, the +12 regulated output is zero, Q9 is off. R54 pulls the base of Q11 high. Since Q10 and Q11 are in a Darlington configuration, both they are turned on. The +12 regulated output begins to rise until Q9 becomes forward biased through voltage divider R50 and R51. At this point, the circuit is in equilibrium. The dynamic resistance of Q10 drops the +16 volt line to the +12 volt regulated output potential. R47 adjusts the voltage at the collectors of Q10 and Q11, providing some adjustment of the output voltage.

-16 VOLT OUTPUT: Diodes CR11 and CR13 form a full-wave rectifier that changes a secondary quasi-square wave to a negative polarity square wave for the -16 volt output. L5 and C19 form a low pass filter to convert the square wave to DC. R10 through R13 are discharge resistors as well as a minimum load to ensure that the filter inductor remains critical at all times. R58, R59, C41, and C42 are two snubber networks used to dampen the "ringing" due to the leakage inductance of T4.

Finally, R23, a rheostat on the supply's daughter board, acts as a "voltage adjust" by changing the voltage at pin 2 of IC1, an input to the error amplifier.

PROTECTION CIRCUITS

CURRENT LIMIT PROTECTION: Transformer T2 is a current-sense transformer that monitors primary current. R14 provides a load for the transformer and converts current to a voltage. Full-wave bridge, CR15 through CR18, converts this quasi-square wave voltage to a positive polarity square wave. R15, a rheostat on the supply's daughter board, is adjusted to extract the amount of voltage that would constitute an overcurrent condition.

R16 and C25 form a low-pass filter and time delay. The time delay prevents false shutdowns for momentary transients. CR19 resets C25 every time primary current falls to zero. During dead time, CR30 is an isolation diode, since the remainder of this circuit is shared with the overvoltage protection circuit. If the voltage of C25 is of sufficient amplitude to exceed the 5-volt reference on the inverting input of comparator IC2C, the output will go high. This forward biases CR30 and CR29; the thyristor, CR29, will latch into conduction pulling its cathode high. This will also pull pin 10 of IC1 high.

A high on pin 10 will inhibit all switching action and the outputs will fall to zero, usually indicating an overcurrent condition. To recover from this condition, the AC power must be turned off and the overcurrent condition corrected before turning the supply back on.

Overvoltage PROTECTION: IC2A is the overvoltage comparator. A 2.5 volt reference is applied to the inverting input of the comparator. The +5 volt output is applied to the non-inverting input of the comparator through voltage divider R39 and R40.

If the +5 volt output exceeds approximately 6.2 volts, the output of the comparator will go high, forward biasing CR32. This will, similar to an overcurrent, forward bias CR29. CR29 will latch and pull pin 10 of IC1 high, causing all outputs to fall to zero. The supply will not restart until the AC power has been turned off and the overcurrent condition corrected before turning the supply back on.

-12 VOLT REGULATOR Overcurrent PROTECTION: IC2B is also used as an overcurrent comparator on the +12 volt regulated output. If the voltage on the output side of R45 drops too low because of an excessive current drain, the output of IC2B will go high, forward biasing CR29.

CR29 will then latch and pull pin 10 of IC1 high, again causing all outputs to fall to zero. The supply will not restart until the AC power has been turned off and the overcurrent condition corrected before turning the supply back on. This circuit has been added because an overcurrent condition on the +12 volt regulated output could destroy Q10 without activating the primary overcurrent circuit.

POWER LINE CONSIDERATIONS

The 115/230 switch located on the rear of the computer is normally set at 115 volts, the normal line voltage in the United States. A 230 volt position is for use in countries that use 220 volts.

Note: There is no need to change the fuse inside the power supply - it is the proper value for both 115 and 230 volt operation.

The plug on the power cord is for standard 115 VAC outlets. For 230 VAC operation in the United States, replace the line cord and connector. When you install the new plug, make sure it is connected according to your local electrical code. Units with three-wire line cords must always have the green wire connected to chassis ground.

OPERATING CHARACTERISTICS

The Z-100 power supply must have a load to operate. The power supply has overvoltage protection, in that it will shutdown if the +5 volt supply increases to 130% (+6.5 volts). It also shuts down if any of the voltage supplies become shorted, but has auto-reset. If a short should occur, simply turn off the computer, correct the short and try turning it on again.

If the power supply should become inoperative, there is a 6 ampere fuse inside, but this rarely blows. The fault is generally traced to one of the semiconductors, particularly the diode pairs, which, if defective, will generally show physical damage - cracking, chipping, or complete disintegration.

Intermittent power supplies are generally caused by cold solder joints or minute hairline cracks around a soldered connection. The power supply's soldered connections are very sensitive to cracking when the associated component is moved or twisted.

SERVICING

The last paragraph of the Z-100 power supply section of the Zenith Hardware Documentation Manual has a note that states:

"*The power supply section of your computer is not considered to be field serviceable.*"

This is because of the **VERY** hazardous voltages present, even after the power supply has been turned OFF. Repairs should only be attempted by personnel familiar with high voltage circuits.

This said, the following pages provide information essential to the proper servicing of your power supply. This data is not complete and may not represent all models. Please pass any corrections to the editor, "*Z-100 LifeLine*".

The Z-110 'Low Profile' Power Supply:

Photo 1.
The Z-110 'Low-profile' Power Supply

So, let me guide you as we clean and check out one of my spare Z-110 'Low-profile' power supplies. We will take pictures as we go.

Remove all the hexagonal screws and remove the case cover.

Remember, the Z-110 power supply will not include the circuitry to support the internal monitor of the 'All-in-one' and I will point out the differences in the photos as we go. The first difference is in Photo 1. There are NO power leads for the internal monitor.

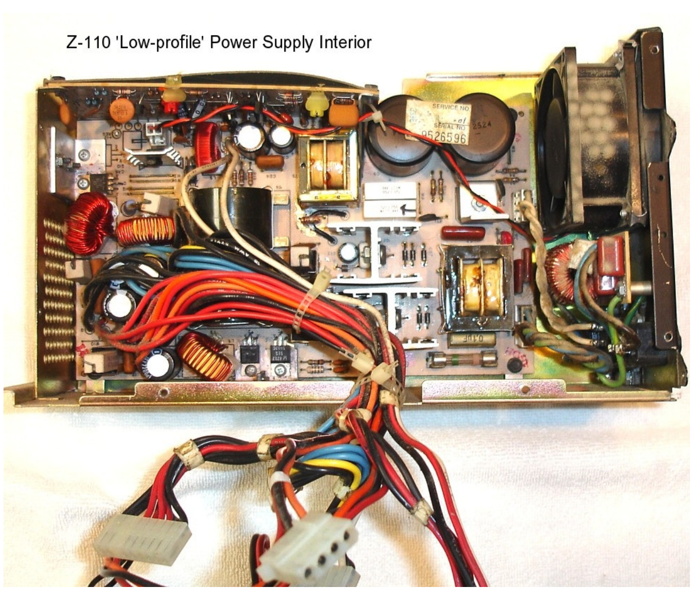


Photo 2 - Internal View

Looking at Photo 2, I am glad that I chose to look into this spare. While I am surprised at how clean this supply was, you can see the layer of dust on the fan assembly. So we will continue taking this one apart and check out the circuit boards for open or bad solder joints, while giving it a good cleaning.

Photo 3 - The Controller Board

The Controller Board of Photo 3 has the low voltage circuits needed to control the high power stuff on the main board. You can see it is located along the top edge of Photo 2. You can also see the missing CRT circuitry in the top left corner. A better photograph is next.

Photo 4 - Missing Internal Monitor Circuitry

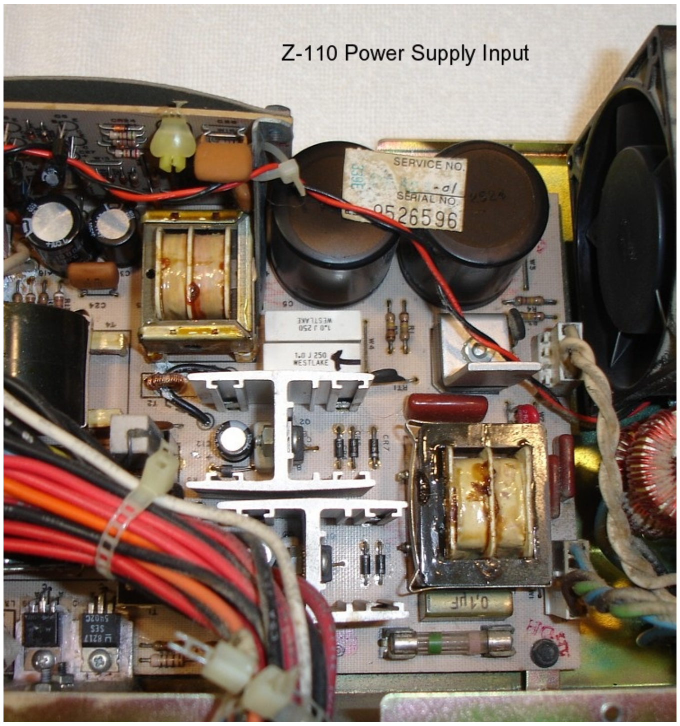


Photo 5 - Filter Capacitors

Take special note of the two huge can capacitors of Photo 5. While these capacitors generally bleed off pretty fast after power down, if there is a failure in the bleeding circuit, these 1000 uF capacitors can pack quite a wallop. Note their location and when you take the circuit board out of the case, you may wish to short the leads with a screwdriver before working around the solder side of the board.

Remove the two screws that hold the fan assembly to the lower case. There are three screws holding the main board to the case, and another screw at the upper left end of the controller board that must be removed to remove the supply assembly from the case. Leaving the fan assembly attached to the main board, use the bundle of wires to lift the assembly from the case without touching the solder side of the main board.

Spread out the entire assembly on your work bench as shown in Photo 6. The wires to the fan assembly are epoxied to their connectors, so rather than pulling them apart, just be careful while handling and leave them attached.

Visually check this side of the board for broken, burned, discolored, or chipped parts. Replace any that appear questionable.

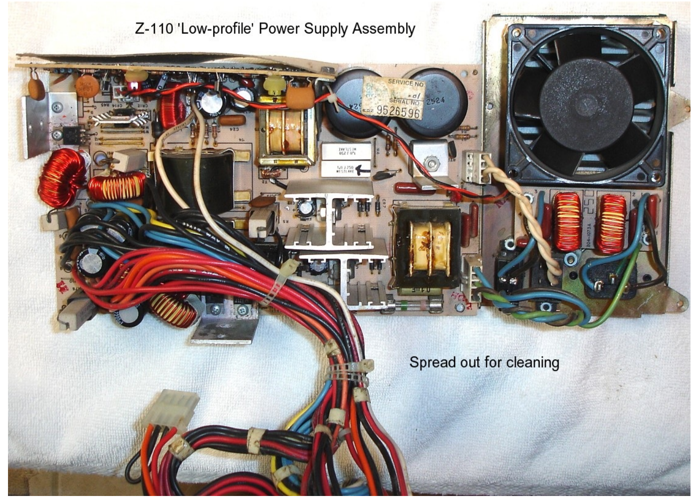


Photo 6 - Spread Out For Cleaning

Photo 7 shows a closeup of the fan assembly and the connections.

Photo 7 - The Fan Assembly

Now we need to flip the entire assembly over to leave the main circuit board solder side up for inspection.

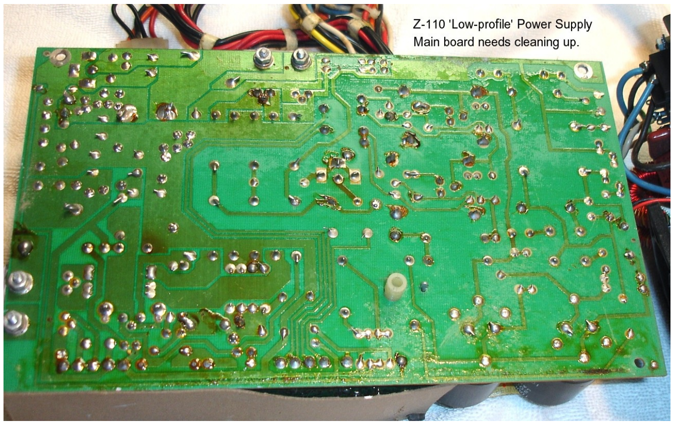


Photo 8 - Solder Side of Main Board

The solder side of the main board still had a lot of flux residue on the pins. It had obviously been hand soldered and then covered by some kind of lacquer.

First off, short to ground the pins to those two capacitors I cautioned about earlier using a screwdriver with an insulated handle. They are now in the bottom right corner of Photo 8.

Gently scrape off all the residue and carefully inspect all solder joints around the various pins. Pay particular attention to the pins of those two capacitors and those huge heat sinks. Being heat sinks, they will expand from the heat and contract again at shutdown and the cycling may eventually crack a joint or two.

Another area of attention is the various pins that hold the daughter board (the controller board) to the main board.

These 3 areas cause about 75% of the failures that I have found in the power supplies. I am actually quite pleased with the reliability of these Power Supplies. Like most things in the Z-100, they are built like tanks to power tanks.

I have NEVER seen a blown fuse... and rarely have found a bad regulator, though I have seen one which had blown apart from something. That supply also had other bad parts, so I assume it was lightning. I had to scrap the entire supply.

With the main board cleaned up, next I like to peek at the controller board. I removed the remaining screw holding the insulating board to the back and again checked for bad or missing solder joints. I have found a few cracked solder joints around those connecting wires to the main board. I have also seen one bad potentiometer and one missing solder joint in the past.

Finally satisfied that I had done all I could, I reassembled the supply and it was ready for testing.

Note: Switching power supplies must have a load to work at all. The load can be a floppy drive, but I prefer to use a motherboard because it uses four different voltages right there.

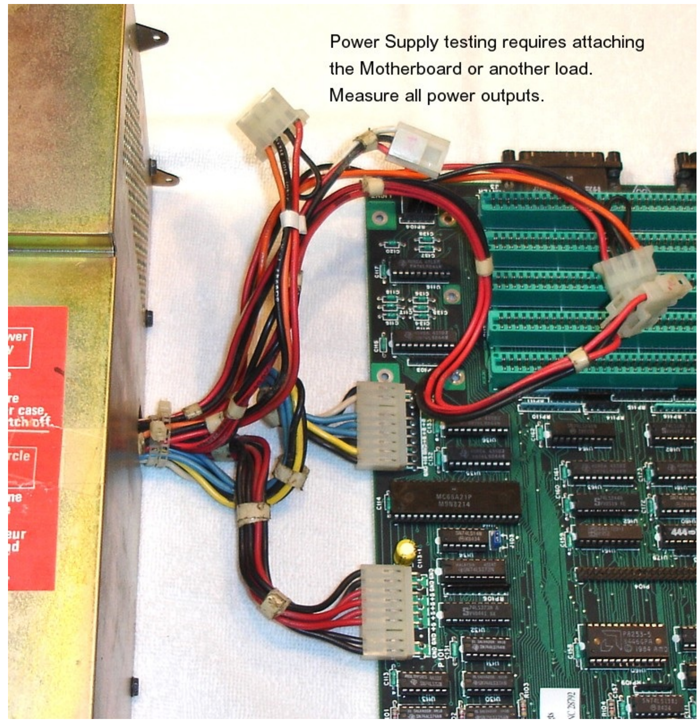


Photo 9 - Power Supply Testing

CAUTION: Please remember to place the cover on any power supply before powering it up for the first time after a lengthy period of time or storage. Parts may have moisture, weakened over time, or, in the case of capacitors, may short out. PARTS CAN EXPLODE! I do the same to any Z-100 that I have not used in awhile. Ever install a can capacitor backward? Talk about an explosion... and smelly smoke!

My supply worked great! Another successful mission. I hope you have success, also.

OK. That was the Z-110 'Low-profile'. Next...

The Z-120 'All-in-one' Power Supply

Photo 10 - The Z-120 'All-in-one' Power Supply

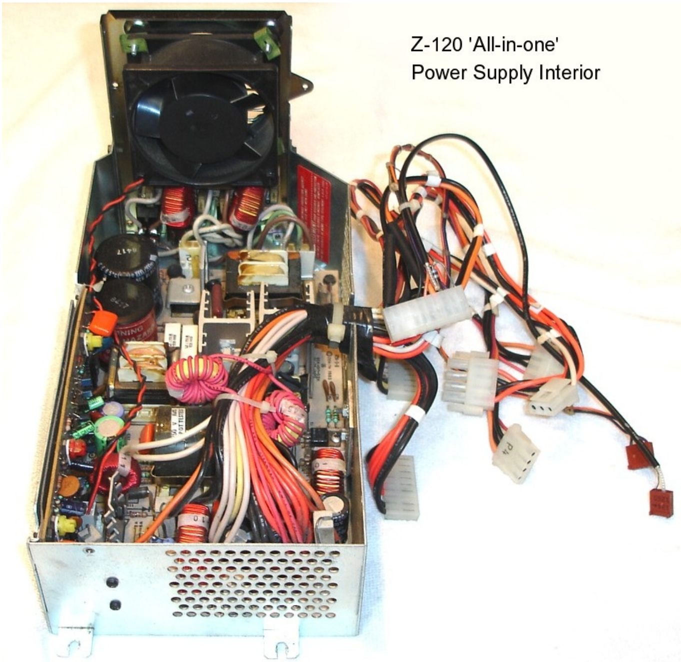


Photo 11 - Internal View

Other than being installed with the main board down in the bottom of the case, and the fan assembly being rotated 90 degrees, there is not much difference. In fact the ONLY difference is the parts for the internal monitor IS INSTALLED in this power supply. In photo 11, you can just make out the large connector that installs to the Video Deflection Board. The other two brown connectors go to the Video Logic Board.

Photo 12 - The Fan Assembly

The Fan Assembly (Photo 12) is exactly the same.

Photo 13 - The Controller Board

The Z-120 ‘All-in-one’ Power Supply Controller Board has the circuitry for the internal monitor CRT installed. You can see the yellow potentiometer, the 12v regulator and the other extra parts in the upper left of Photo 13 and in 14.

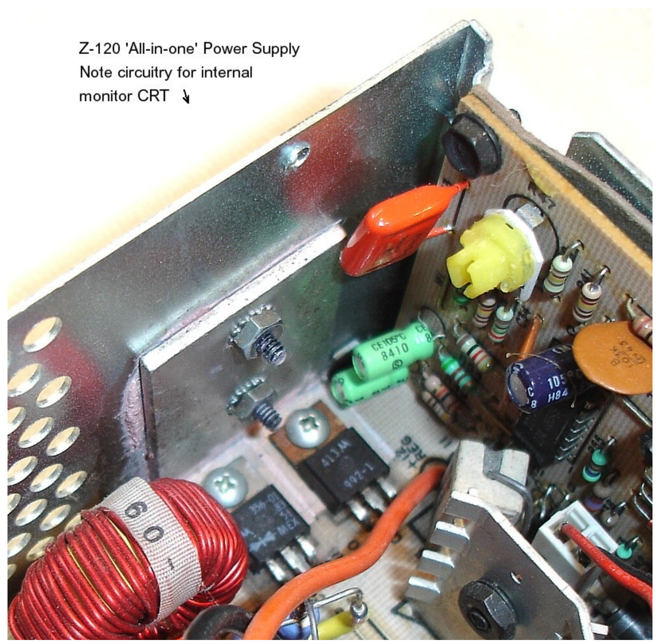


Photo 14 - The Internal Monitor Circuitry

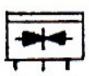
Well, that about does it. I have all the parts that you may need. If you have a problem, email me at:
z100lifeline@swvagts.com

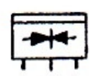
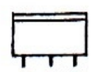
Cheers,
Steven W. Vagts

Table 1 - OUTPUT VOLTAGES

The following voltages were taken from a normally operating Z-100 under the following conditions:
- Computer at idle, or doing memory test.
- Gemini board and dual floppy drives installed.
- 768K ram, 64K video, 5 MHz motherboard, V3.2 ROM chip.
- Hard drives (each was 10 watts) were used as load increments.
- Meter ground lead is connected to chassis ground.

Rating:	No Hard Drive:	1 Hard Drive:	2 hard drives:
+ 5v, 12.0A dc	+ 5.00 Vdc	+ 5.00 Vdc	+ 5.01 Vdc
+ 8v, 8.0A dc	+ 9.09 Vdc	+ 9.45 Vdc	+ 9.84 Vdc
+12v, 5.2A dc	+12.63 Vdc	+12.59 Vdc	+12.54 Vdc
+16v, 1.0A dc	+18.47 Vdc	+19.16 Vdc	+19.93 Vdc
-16v, 1.0A dc	-18.88 Vdc	-19.55 Vdc	-20.3 Vdc
+12v reg, 1.5A dc	+11.96 Vdc	+11.96 Vdc	+11.97 Vdc
R47 wiper & right leg	+17.42 Vdc	+18.12 Vdc	+18.87 Vdc
left leg	+ 6.39 Vdc	+ 6.65 Vdc	+ 6.92 Vdc
R15 wiper (center)	+ .76 Vdc	+ 1.09 Vdc	+ 1.45 Vdc
left leg	+ 1.41 Vdc	+ 2.02 Vdc	+ 2.68 Vdc
R23 wiper (center)	+ 2.51 Vdc	+ 2.52 Vdc	+ 2.52 Vdc
right leg	+ 3.32 Vdc	+ 3.33 Vdc	+ 3.33 Vdc
left leg	+ 1.78 Vdc	+ 1.79 Vdc	+ 1.79 Vdc

Other voltages:		DC voltages:	AC voltages:
Q1 shield		+160.0 Vdc	2.8 Vac
R7 lead		+ 9.5 Vdc	
R61 lead		+ 19.3 Vdc	
CR2 banded lead		- 3.9 Vdc	95.7 Vac
CR4 banded lead		-161.0 Vdc	2.8 Vac
CR6 banded lead		+160.0 Vdc	2.8 Vac
CR11 banded lead			24.0 Vac
CR12/CR14 shield		+ 19.4 Vdc	21.3 Vac
CR8  A C A	A		11.8 Vac
	C	+ 9.6 Vdc	10.0 Vac
CR10  A C A	A		15.9 Vac
	C	+ 12.6 Vdc	14.5 Vac

		DC voltages:	AC voltages:
Q2 shield		- 1.8 Vdc	96.0 Vac
R45 lead		+ 19.3 Vdc	
R77 lead		+ 19.3 Vdc	
CR3 banded lead		- 2.9 Vdc	95.7 Vac
CR5 banded lead		-161.0 Vdc	2.8 Vac
CR7 non-banded lead		-160.0 Vdc	2.8 Vac
CR11 non-banded lead		- 19.7 Vdc	21.3 Vac
CR9  A C A	A		6.6 Vac
	C	+ 5.1 Vdc	5.7 Vac
Q10  B C E	B	+ 12.7 Vdc	
	C	+ 18.4 Vdc	
	E	+ 12.1 Vdc	

NOTES: R23 affects all voltages, including +12V reg - "voltage adjust".
Excessive adjustment of R47 will cause shutdown.
Voltages generally increase as the load increases.

Z-110/Z-120 POWER SUPPLY PARTS LIST

Resistors:			Capacitors:			Rectifiers:	
R1-R4	110KΩ	1/2w	C1	.1µF	275v	CR1	(next page)
R5	51Ω	7w	C2	.1µF	250v	CR2-CR5	#344-00, 1N4933
R6	330Ω	1/2w	C3-C4	.0047µF		CR6-CR7	#344-06, 1N4937, ECG552, SK9000
R7	22Ω	5w	C5-C6	1000µF	200v	CR8	(next page)
R8-R9	not used			C7-C8	1.0µF	200v	CR9
	(next page)						
R10-R13	910Ω	1/2w	C9-C10	.27µF	100v	CR10	(next page)
R14 (2)	150Ω	1/2w	C11-C12	22µF	100v	CR11	(next page)
R15(adj)	1KΩ		C13	.0033µF	1Kv	CR12/CR14	(next page)
R16-R18	2.7KΩ		C14	3300µF	16v	CR13	(next page)
R19	20KΩ		C15	not used		CR15-28	#R142, ITT142, ECG177, SK9091
R20	51KΩ		C16	2200µF	10v	CR29	(next page)
R21-R22	2KΩ		C17	2200µF	16v	CR30	#R142, ITT142, ECG177, SK9091
R23(adj)	2KΩ		C18	2200µF	25v	CR31*	#R142, ITT142, ECG177, SK9091
R24-R27	2KΩ		C19	1000µF	25v	CR32	#R142, ITT142, ECG177, SK9091
R28	2.7KΩ		C20-C24	.1µF	100v	CR33	#347-03, 1N4001, ECG116, SK3311
R29-R30	not used			C25	1.0µF	50v	CR34
	not used						
R31-R32	300Ω		C26	.027µF	130v	CR35-CR38	#R142, ITT142, ECG177, SK9091
R33-R34	470Ω	1/2w	C27	10µF	25v		
R35	1KΩ		C28	.1µF	130v		
R36	2.7KΩ		C29	.01µF		Transistors:	
R37*	2.7KΩ		C30	.0047µF	100v	Q1-Q2 (NPN)	(next page)
R38	2.7KΩ		C31	10µF	25v	Q3-Q4 (NPN)	(next page)
R39	1240Ω		C32	.01µF		Q5 (NPN)	(next page)
R40	825Ω		C33	.1µF	130v	Q6 (PNP)	(next page)
R41-R42	1240Ω		C34	.01µF		Q7 (NPN)	(next page)
R43-R44	not used			C35*-C36*	10µF	25v	Q8 (PNP)
	(next page)						
R45*	1Ω	5w	C37	470µF	25v	Q9* (NPN)	(next page)
R46	not used			C38	.01µF		Q10* (NPN)
	(next page)						
R47(adj)*	2KΩ		C39-C42	.001µF	1Kv	Q11* (NPN)	(next page)
R48*	510Ω		C43	820pF			
R49*	10KΩ		C44	100µF	10v	Transformers:	
R50*	499Ω					T1	#95-3600-04
R51*	432Ω		Inductors:			T2	small coil
R52*	1.2KΩ		L1 #95-3602			T3	#95-3609-03
R53-R54*	510Ω		L2 Toroid choke -30 (18.5µH)			T4	#95-3609-02
R55	4.7KΩ		L3 Toroid choke -07 (104µH)			T5	#95-3601-03
R56-R59*	100Ω	1/2w	L4 Toroid choke -10 (296µH)				
R60	10KΩ		L5 Toroid choke -11 (827µH)				
R61(2)	56Ω	2w	L6 Toroid choke -09 (60.5µH)			Aux board 1073-01C:	
w/Zener diode #279-13					R1	1 Meg	1/2w
R62-R75	not used						C1
	.0047µF	250~5Kv					
R76	24Ω	10w				C2	0.1µF
	275v						
R77	75Ω	5w	IC1 #SG3524N (next page)			C3-C5	.0047µF
	250~5Kv						
			IC2 #221-121 (next page)			L1-L2	Toroid chokes -36
RT1-RT2	#930-01, 5Ω cold		MOV1	ZNR 7K431U		Pink +5v wires:	
	Toroid chokes -45						

F1 Fuse: 250V, 6 Amp, such as AGC6, SOCSS6, or 6A 250V 312.

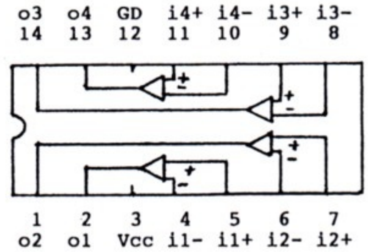
NOTES:

- An * indicates that the part is found in Z-120 Power Supplies only.
- All resistors are 1/4 watt, except as indicated.
- R14 in the Z-120 consists of 2 150 ohm, 1/2 watt resistors; in the Z-110 it consists of a 75 ohm, 1 watt resistor.
- R33 & R34 in the Z-110 model are 1 watt resistors.
- RT3 in schematic is replaced by R61 assembly in later models:
  - -- R61 in the Z-120 consists of 2 56 ohm, 2w resistors and a 5 volt zener diode in parallel.
  - -- R61 in the Z-110 is a 30 ohm, 5w resistor and a 5 volt (#279-19) zener diode in parallel.
- Replacement part #s are given, if known, in parentheses.
- Other parts differ in value between the above and in schematic: R45, R50, R51, R76, C25, C27, & C29

SEMICONDUCTOR DIAGRAMS:

IC: IC1
Markings: SG 3524N or LM 3524N
H/Z Part #: 221-234
ECG #: ECG 1720 (pinout in text)
RCA #: SK9983
Other #:

IC2
221-121
221-121
ECG 834
SK3569
ECG 5316
276-1712
GI212-152-03



Transistor: Q1 & Q2
Type: (NPN - si)
Markings: 1087-1
H/Z Part #: 2N6740
ECG #: ECG 379
RCA #: SK9085
GE #:

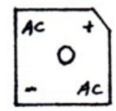
Q3,Q4,Q9,Q11
(NPN - si)
1093
121-975
ECG 123AP
SK3854

Q6 & Q8
(PNP - si)
1095
436-1095/2N4403
ECG 159
SK3466
GE-82

Transistor: Q10
Type: (NPN - si)
Markings: 992-1
H/Z Part #: 121-992-01
ECG #: ECG 291
RCA #: SK3054/196
GE #: GE-302

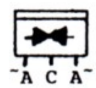
Q5 & Q7
(NPN - si)
1093
2N4401
ECG 123AP
SK3854

Bridge: CR1
(600 PRV, 8A Bridge rectifier)
GI 212-152-03
ECG 5316



Rectifier: CR8
Markings: 356-01
H/Z Part #: GI1664
ECG #: ECG 6240

CR9
351-07
GI1645



Rectifier: CR10
Markings: 356-01
H/Z Part #: MUR1610
ECG #: ECG 6240
RCA #: SK5060
GE #:

CR11 & CR13
316-04
MR-852
ECG 506
SK3925
GE-511

CR12/CR14
358-03

Rectifier: CR29
Markings: 185-10
H/Z Part #: 2N5060
ECG #: ECG 5400
RCA #: SK3638/5402
GE #: GEMR-5

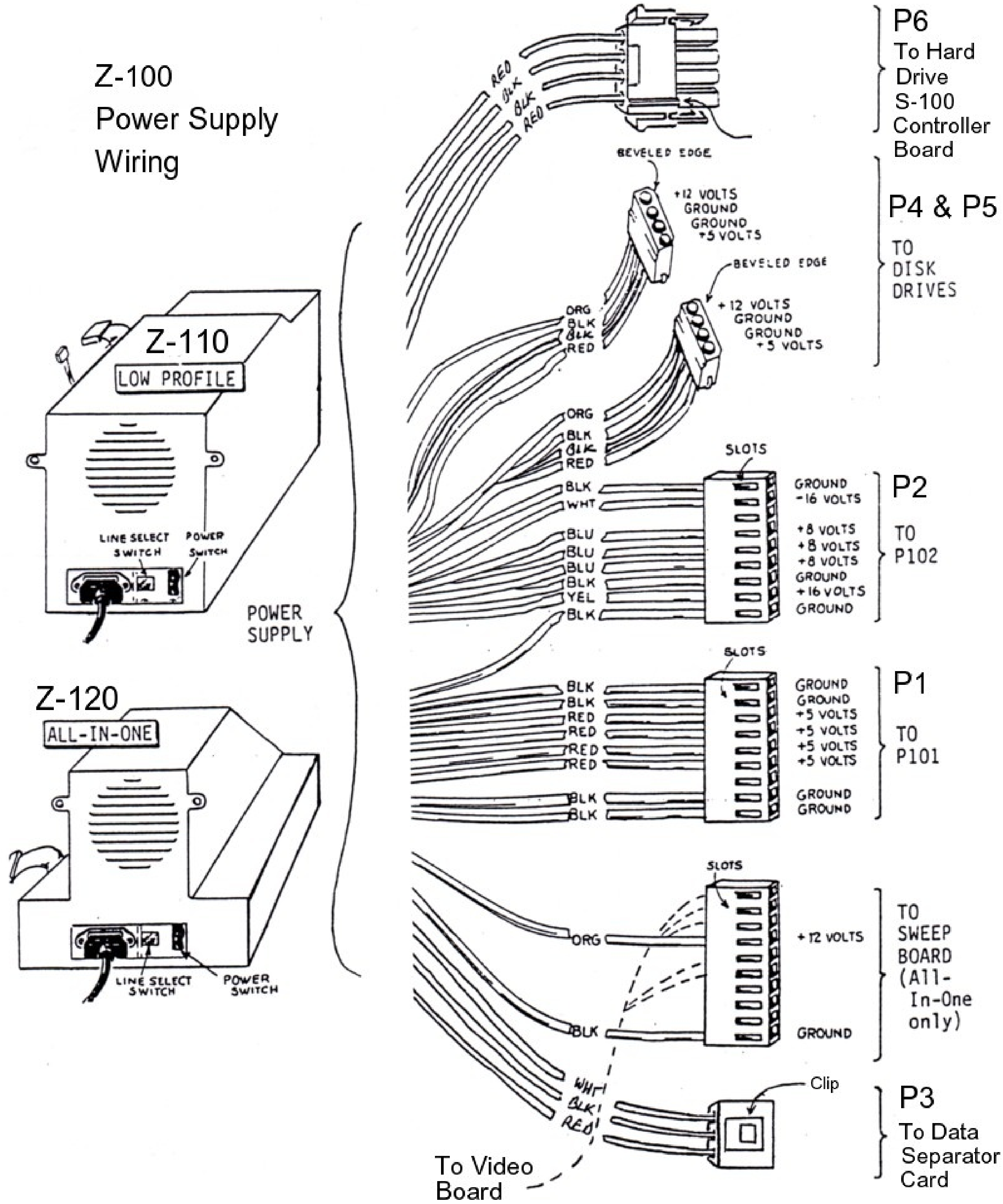


Figure 2. Z-110 / Z-120 Power Supply Exterior Wiring

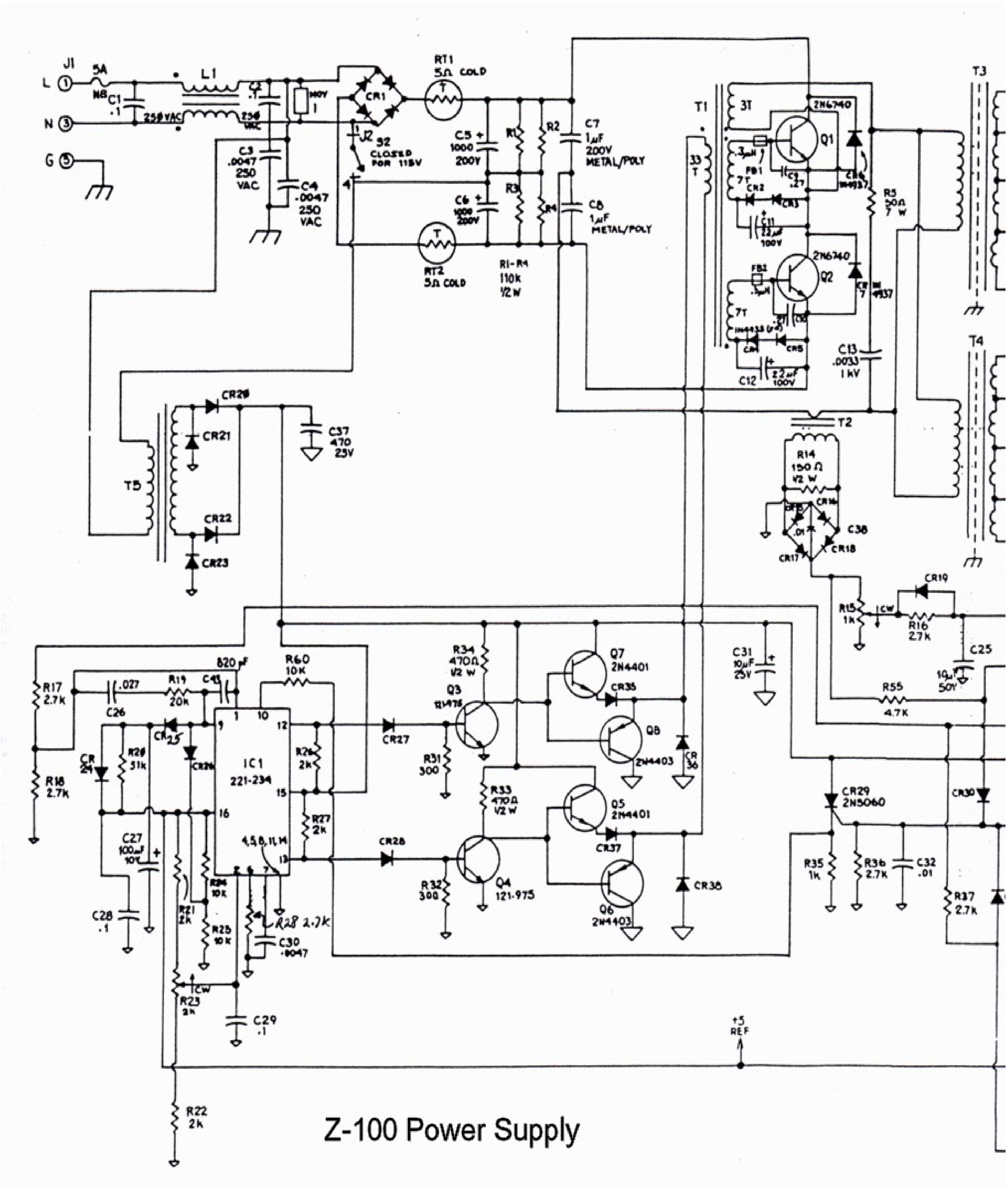


Figure 3a. Z-110 / Z-120 Power Supply Schematic

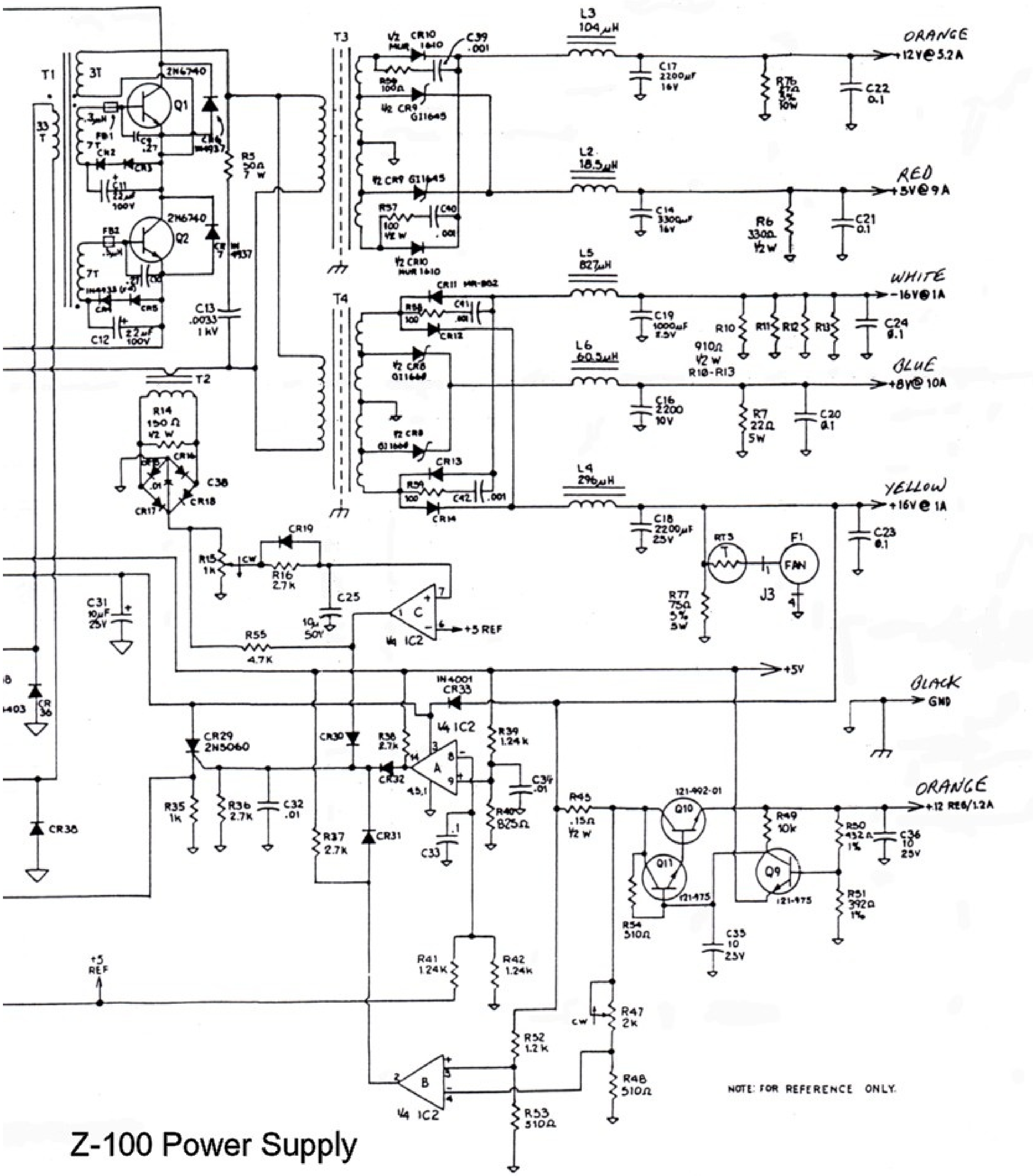


Figure 3b. Z-110 / Z-120 Power Supply Schematic