Chapter 2

The Power Supply

An unreliable power supply can play havoc with a computer. Yet the power supply is so common - and inconspicuous - that it is taken for granted and seldom suspected in case of a problem. Since nothing else can work without the power supply, let us start with it.

2-1. Discussion

The SK68K requires three power supply voltages. But it is difficult to say exactly how much current it needs at any specific time, since this depends on how far along you are in constructing it, and also on how many plug-in expansion boards are installed in the six XT-compatible connectors.

A fully configured SK68K, with a full 1 megabyte of memory and all on-board options, requires the following:

+5 volts for the main TTL and MOS logic.

+12 volts for the RS-232C serial port, and for some of the I/O circuits.

-12 volts for the RS-232C serial port, and for some of the I/O circuits.

These voltages can be supplied from one or more regular power supplies, but the simplest and cheapest is a 135-watt or 150-watt switching power supply of the type designed for XT clones.

Types of Power Supplies

Switching power supplies are substantially smaller and more efficient than the old-fashioned “linear" power supplies. The block diagram of Fig. 2-1 shows the difference between the conventional linear supply and a switching supply.

The conventional linear supply begins with a step-down transformer, which steps the 115 volts AC from the power line to a more manageable voltage, slightly above the desired DC output voltage. The resulting AC is

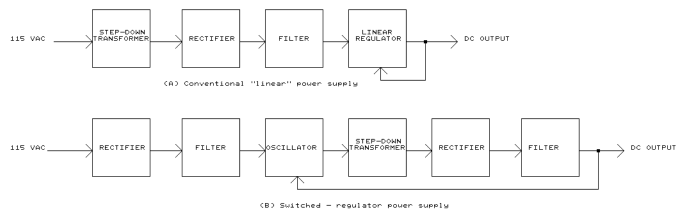

Fig. 2-1. Types of power supplies.

then full-wave rectified, filtered, and then fed to a linear regulator. The most common regulator contains a pass transistor in series with the output, controlled by a voltage comparator which compares the DC output voltage against a reference voltage. The comparator then biases the pass transistor to change its resistance; it thus uses the voltage drop across the transistor to keep the output DC voltage constant. If the output voltage is too low, it makes the pass transistor conduct more; if the output voltage is too high, it biases the pass transistor so it conducts less.

There are three main problems with such a linear circuit:

(1) Since the AC line operates at 60 Hz, the step-down transformer must be fairly large and heavy. It must have enough iron in the core so as not to saturate at the low frequency.
(2) The filter capacitor must also be fairly large so as to remove the ripple, which occurs at twice the line frequency. Although the capacitor need not remove all the ripple (since the regulator can remove the rest), it must remove enough ripple to make sure the voltage fed to the regulator does not drop too far.
(3) The regulator's pass transistor conducts current at all times, and therefore dissipates power. To safeguard against the voltage dropping too far, the voltage level into the regulator must be at least several volts more than the desired output, so the power dissipated by the pass transistor may be considerable.

None of these problems is major, but it does mean that a linear power supply to provide a substantial amount of power must be fairly large and heavy, and must dissipate a substantial amount of power.

The switched-regulator supply of Fig. 2-1 (B) is substantially more complex. It starts with a rectifier and filter, which directly change the incoming 115 volts AC into DC at between 110 and 150 volts. This DC then powers an oscillator, which generates a high voltage AC at a frequency of several kHz. This signal is then stepped down through the transformer, rectified, and then filtered.

Regulation is achieved by again comparing the DC output of the supply against a reference voltage in a voltage comparator, and using the resulting output to control the pulse-width of the oscillator.

This circuit has several advantages over the linear supply:

(1) Since the transformer works at several kHz, rather than at 60 Hz, it requires a smaller iron core. A small toroid can be used with less loss and less cost.
(2) Likewise, the final filter capacitor can be small since the ripple frequency is much higher than in the linear supply. (Although a second filter is

needed in the input circuit, the oscillator will tolerate a large amount of ripple and thus a small capacitor can be used here as well.)

(3) Although the oscillator transistors indirectly provide regulation of the output, they do not operate in the linear region as the pass transistor would in a linear power supply. They are always either cut off or saturated, and so their power dissipation is much lower than in the linear region.

The result is that a switching power supply, although much more complex than a linear supply of the same output power rating, is generally much smaller and lighter, and runs much cooler. For example, a 135-watt or 150-watt power supply of the type often used in XT clones weighs only a fraction as much as an equivalent supply used to weight before switching power supplies became popular.

Needless to say, switching supplies do have some disadvantages. The major ones are this:

(1) Because the oscillator operates at fairly high powers and high frequencies, it can produce interference with nearby radio or television receivers. The 115-volt input to the power supply must therefore be well filtered to prevent high frequency signals from being transmitted back into the power supply; additional filtering is also needed on the dc outputs as well, and the supply must be well shielded.

(2) Since the supply does not have a large output filter capacitor, it does not do well when the output current suddenly changes. In a conventional power supply, the output capacitor easily handles sudden surges in power; transient response of switching supplies tends to be slower. The lack of a large filter capacitor also means that switching power supplies are also much more susceptible to short power outages. For example, some users may use a UPS (Uninterruptible Power Supply) or standby power supply in case of main AC power failure. Such power supplies often delay a anywhere from 15 milliseconds to as much as 1/2 second after a main power failure before they switch in to provide power. The large filter capacitor in a linear power supply may be able to provide power to tide the computer over during this interval; in a switching power supply, there is no such storage capacitor and so the dc power may just totally disappear for this fraction of a second.

(3) Multi-output power supplies (such as an XT supply which provides four different output voltages) often derive all their output voltages from the same regulator and transformer. In other words, the switching regulator in an XT power supply controls all four outputs at the same time. Typically, it regulates only the +5-volt output, while the other three outputs are allowed to vary somewhat. For example, if the load on the +5-volt output goes up, the switching regulator increases the output of all four supplies at the same time. The +5-volt output may thus stay constant, but the other three outputs rise. Some power supplies try to compensate by providing low-power linear regulators on the other outputs, but this obviously limits their output capacity. In most XT-type power supplies, the fan is powered from the +12-volt supply; you can

often hear it speed up or slow down slightly as the switching regulator changes its pulse width to keep the +5-volt output constant.

(4) Switching regulators do not work very well if there is no load. Most XT-type power supplies therefore have a protection circuit which turns off the entire power supply when the load is removed; the same circuit also turns off the supply if the dc output is shorted.

SK68K Power Supply Connector Pinouts

The XT-type power supply has six dc output connectors, two for the electronics and four for disk drives.

Two six-pin connectors plug into the main computer board (J10A and J10B in the right rear corner of the board). The only reliable way to differentiate between them is by the colors of the wires. In order, their 12 connections are as follows:

Pin number	Color	Function
		J10B
1	Orange	Power Good (not used - see text)
2	-	No Connection
3	Yellow	+12 volts DC
4	Blue	-12 volts DC
5	Black	Ground
6	Black	Ground
		J10A
1	Black	Ground
2	Black	Ground
3	White	-5 volts DC (not used)
4	Red	+5 volts DC
5	Red	+5 volts DC
6	Red	+5 volts DC

These connectors provide two outputs which will not be used by our computer - a “power good" output which could have been used to detect that primary (115-volt) power has just disappeared and the dc outputs are also about to disappear, and a -5-volt output which is simply not needed.

The remaining four power supply connectors are all wired identically as follows:

Pin number	Color	Function
1	Yellow	+12 volts DC
2	Black	Ground
3	Black	Ground

Pin number	Color	Function
4	Red	+5 volts DC

5-1/4" floppy and hard disk drives all use the same wiring, so such a power supply can directly power as many as four such drives (assuming that it has enough power handling capacity.) 3-1/2" drives use a different connector and pinout, and an adapter cable has to be used.

2-2. Construction

Before proceeding with actual work, it's important to set things up so the SK68K printed circuit board can be worked on easily, yet is protected from accidental short circuits and other possible damage.

The best way to do so is to is to mount the board and its power supply on a wooden board about 12" by 24", as shown in Fig. 2-2. Hammer two brads into the board as shown to hold the printed circuit board in place. Be sure to use the correct two holes to avoid a possible short circuit. (The location of the two brads in Fig. 2-2 is shown with the small triangular flags on the brads.)

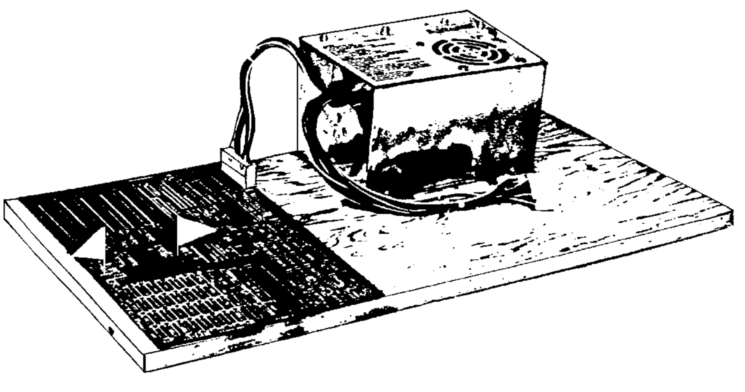

Fig. 2-2. One way to mount the board and supply.

Note how the board is oriented - power connector J10 is right next to the power supply, and the six expansion connectors are in the left rear corner. We will use the words left, right, front, and back to describe the board when it is positioned like this (it will fit into a PC clone cabinet the same way). For example, U92 is in the back, while C47 is in the front left corner. (Look at the silk-screen printing on the board to see how the components are positioned on the board.)

Note also that the side with all of the white lettering - this is called the silk-screen layer - is on top, whereas the other side of the board will be called the bottom. All of our soldering will be on the bottom side -there are no solder joints whatever on the top or silk-screen side of the printed circuit board.

Soldering itself is more of an art than a science. Even if you consider yourself to be an expert, read Appendix C for our hints on how to keep bad soldering from ruining your SK68K project.

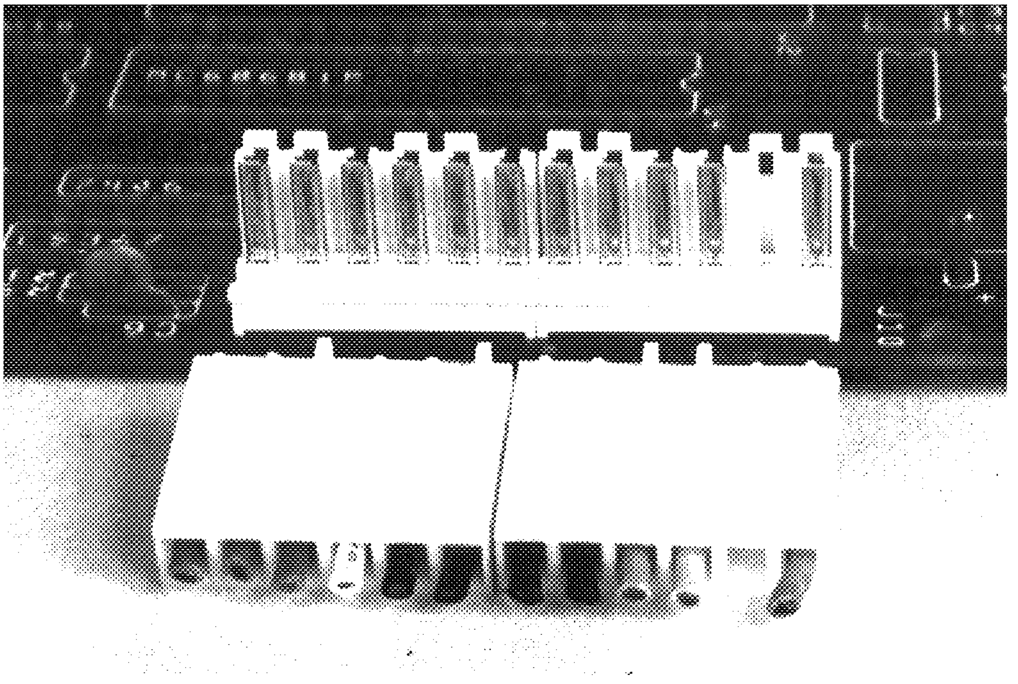

Fig 2-3. Power connectors and plugs. Note how the tabs match

The Power Connector

The power connector, J10, actually consists of two six-pin connectors, J10A and J10B, in the right rear corner of the board. They are shown in Fig. 2-3, J10A on the left and J10B on the right. Read the following paragraphs before you do anything.

The power connectors are a potential source of big problems. If you look at the connectors you have, you will note that the two board-mounted connectors are identical, and the two power supply plugs are probably identical as well. In other words, it is extremely easy to make a mistake and plug the wrong power supply plug into the wrong connector on the board and burn up the board. We have to make sure that never happens.

First, look at the two power supply plugs. You will see that one of them has six wires, while the other has only five - the next-to-the-last wire is missing. Note also that we have cut off the next-to-the-last pin on J10B in Fig. 2-3 (compare it with your connectors). Though this doesn't really prevent a mixup, it does serve to remind us what goes where.

Next, compare the tops of J10A and J10B in Fig. 2-3 with the actual power connectors in your parts kit. In the plastic, behind each of the metal pins, is a small rectangular opening with a tiny plastic 'bridge' above it. Your connectors will still have all of these bridges, while some of the bridges are shown cut off in Fig. 2-3. Now look at the two matching power supply plugs, which will have six small plastic tabs sticking out the long side. These tabs may all still be there, or some of them may already be cut off. When all the plugs and connectors are brand new, the tabs on the plugs prevent them from being inserted into the pc-mounted connectors because the long tabs hit the bridges. The object is to cut just the right combination of tabs and bridges so the six-wire plug only fits J10A, and the five-wire plug only fits J10B. If you look closely at Fig. 2-3, you will see that we have done exactly that. (The whole thing is complicated by the fact that the power supply plugs may already have some tabs cut off, so you may have to take that into account.)

One useful piece of information: when properly installed, the black wires of the two connectors are adjacent to each other.

Now that you know what has to be done, install the following components:

J10A and J10B	Solder the two connectors to the board as in Fig. 2-3, and then match up the bridges and tabs so the power supply plugs in only one way. Make sure that the connectors are oriented the correct way, so that the metal pins are visible from the edge of the board, as in Fig. 2-3, and that the 5-wire plug only fits J10B.
C65	10 µF tantalum capacitor; make sure that its positive lead (marked by a + sign) is closer to J10, as tantalum capacitors have a nasty habit of exploding if connected backward!
C6	0.1 µF disk capacitor near J10
C3, C4, and C5	47 pF disc ceramic capacitors
C68	33 pF disc ceramic capacitor

Although not part of the power supply, the 47 pF and 33 pF capacitors are very similar to the many 0.1 µF capacitors, and this gets them out of the way so you will not confuse them later.

Aside from one 1 µF tantalum capacitor, all the remaining capacitors are 0.1 µF disc ceramics. Digital circuits are notoriously 'noisy', and computer designers have learned the hard way that it is necessary to install small bypass capacitors between the +5-volt line and ground all over a board to keep that noise off the power lines. A general rule of thumb is that one such capacitor should be installed for every two or three digital ICs. We will instruct you when to install these additional capacitors.

2-3. Testing

We will do no testing at this stage; the power supply will be tested in the next Chapter.