At the Repair Bench – Heathkit® IP-2718 Power Supply – September 2023

Figure 1- Heathkit® IP-2718 Tri-Power Power Supply

Last month (in July 2023), I received an e-mail from a ham in Presque Isle, Maine, asking me if I would be interested in taking a look at an older Heathkit® IP-2718 Tri-Power Supply (Figure 1) that was not operating properly. I agreed to give it a shot, and had the owner ship the PSU to me. A rather compact power supply that weighs in at a mere ten pounds, the IP-2718 is a three-output unit, having a 5VDC fixed output and a pair of identical 0V to 20VDC adjustable outputs. The two 20-volt outputs can be operated independently, or they can be set so that the "A" output tracks the "B" output. The 5VDC output is at 1500mA, while the 20VDC outputs are at 500mA each. The three outputs are all individually floating outputs which can be connected together in a wide variety of methods, whether in series, in parallel, or in any one of a number of series/parallel combinations. As a result, it is possible for example to achieve a developed output of -5VDC to -45VDC at a maximum output current of 500mA.

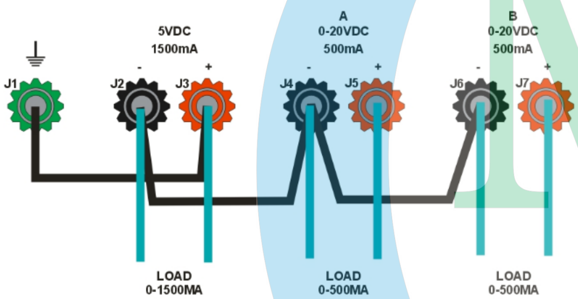

Figure 2 - Circuit example #1

Figure 2 illustrates one of the many configurations possible. In this configuration, the +5V terminal is referenced to ground, and each of the 0 to +20V supplies are referenced to -5 volts. In this manner, each of the positive-going 20-volt supplies can be varied from -5VDC to +15VDC, or an overall span of 20 volts. Output currents for each of the three supplies are as shown in the Figure 2 diagram.

In another example, shown in Figure 3, we see the three outputs connected in series with the ground reference made at the high end of the series circuit string. In this circuit, the output voltage is adjustable from -5VDC to -45VDC, while the maximum output current is limited by the maximum current outputs of the "A" and "B" supplies to 500mA.

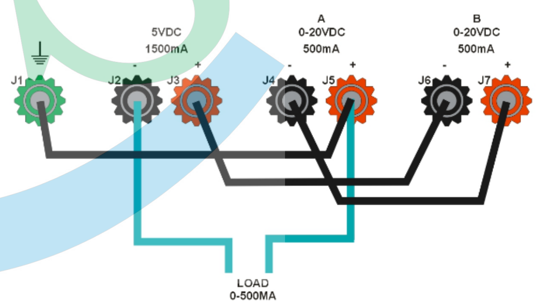

Figure 3 - Circuit example #2

A third example can help to bring home the concept of multiple configurations yielding multiple outputs. In this example, shown at Figure 4, the supplies are connected in such a manner as to produce three separate outputs, a fixed +5VDC output at 0-1500mA current, the "A" 20-volt supply provides an output that is adjustable from 0V to +20VDC at 500mA, and the "B" 20-volt supply outputs an adjustable 0V to -20VDC also at 500mA. Note that the polarity of these three

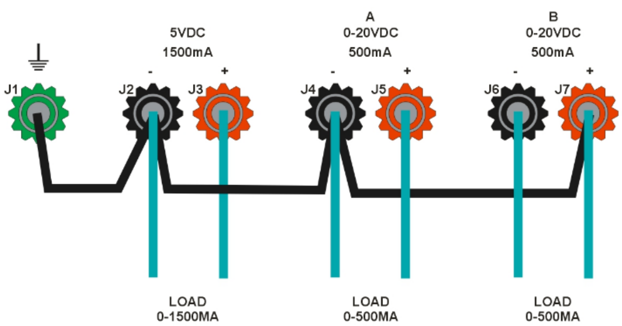

Figure 4 - Circuit example #3

outputs is dependent upon which terminal of each supply is connected to the green ground terminal. A careful look at Figure 4 will show that J2 and J4 – both negative terminals – are connected to ground, thus referencing those two supplies as positive-going outputs, but in the "B" supply, terminal J7 – a positive terminal – is connected to the ground point, thus referencing that output as a negative-going output.

Let's take a look at yet another arrangement, in which we take the two 20-volt supplies out in parallel, thus allowing the currents of these two supplies to effectively add together, resulting in a nominal 1000mA output from the parallel pair. In Figure 5, we can see that a pair of current-sharing or equalizing resistors of 0.5Ω each is connected in series with each of the two 20-volt supplies' positive terminals feeding the positive side of the load. The total output voltage is reduced by the voltage drops of these two resistors. The actual amount of those voltage drops will be determined by the spontaneous current draw of the circuit, as calculated via the Ohm's Law formula of $E = I \times R$. For example, if the circuit current draw is 946mA and if it were to be drawn exactly evenly from each of the two supplies (an unlikely circumstance), the voltage drop across each resistor would be $(0.946/2) \times 0.5$, or $0.2365V$. This would mean that the total voltage dropped across the two resistors would be $0.473V$, or just under a half of a volt. That is the amount by which the total output voltage would be reduced in this configuration and at that specific current draw value. Of course, due to component tolerances and other related factors, the likelihood of having exactly half of the current provided by each of the 20-volt supplies is very slim, and is in fact almost impossible. However, the difference will be small enough that it should not have any meaningful impact on the circuit.

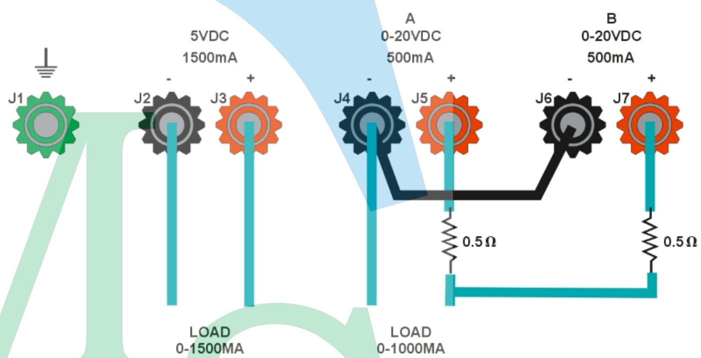

Figure 5 - Circuit example #4

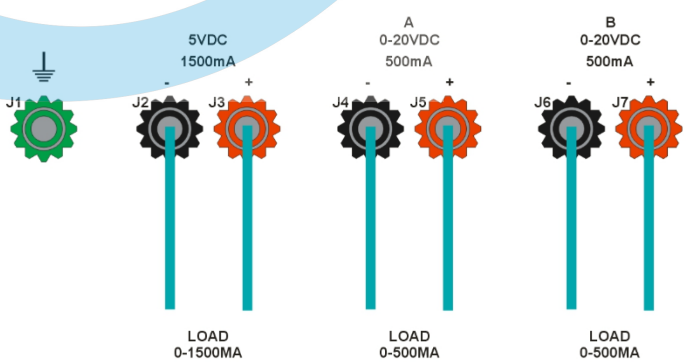

Figure 6 - Circuit example #5

In one final example, we will look at the circumstance wherein we have one of the two 20-volt supplies tracking the other as to output voltage. In this particular power supply, the "A" output will track the "B" output when the unit is placed in the *"TRACKING"* mode. Under these conditions, each of the outputs is floating. However, almost any combination of series-connected outputs can be utilized in the tracking mode. The main take-away here is that the two 20-volt supply outputs need not be adjusted independently, as in this mode, whatever output voltage level the “B” supply is producing, the “A” supply will do the same.

OK – enough about how this supply is intended to operate. Now let’s talk about what it was *not* doing, or was doing improperly. To start with, the 5-volt supply exhibited heavy ripple and low output voltage. In addition, the 20-volt “A” supply had no output voltage at all, and the 20-volt “B” supply exhibited an output voltage that was too high and could not be adjusted to its proper value.

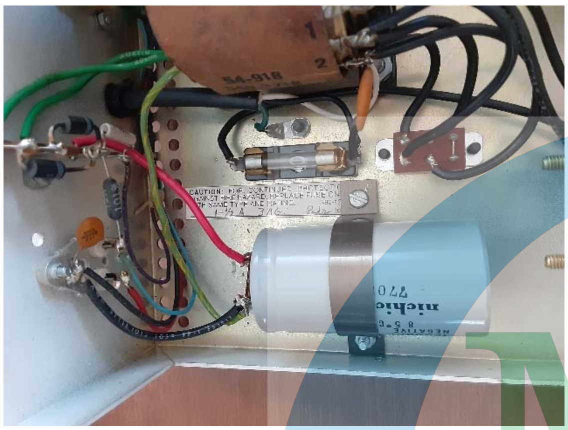

Figure 7 - 5VDC supply components

Under the cover here, there are three separate power supplies that are integrated within this unit. The 5-volt supply consists mainly of an LM309K three-pin voltage regulator IC, a pair of 1N5403 silicon diodes forming a full-wave rectifier, and a 12,000µF 15V aluminum electrolytic capacitor. In this case, diagnosis was easily accomplished because there was so little that *could* go wrong. As it turned out, the capacitor was extremely leaky, causing the ripple and also causing the failure of one of the two diodes in the full-wave rectifier. It was a no-brainer that both diodes should be replaced, as they were both placed under the same stresses. This portion of the IP-2718 is constructed with point-to-point wired components (Figure 7), so replacement was extremely simple. The 12,000µF capacitor (C2) has a 220Ω one-watt bleeder resistor placed across its terminals, the edge of which is just barely visible in the Figure 7 photo. The rear panel of the enclosure has a terminal tie strip on which are the two diodes of the full-wave rectifier. Replacement of the capacitor and the two diodes resolved the issues with the 5-volt supply. I did have to do a little bit of customization, as the replacement capacitor has screw terminals rather than the solder lugs of the original device. That was handled by putting solder lugs onto each of the leads that needed to go onto the capacitor, and then simply putting those lugs under the screws and tightening them down in place.

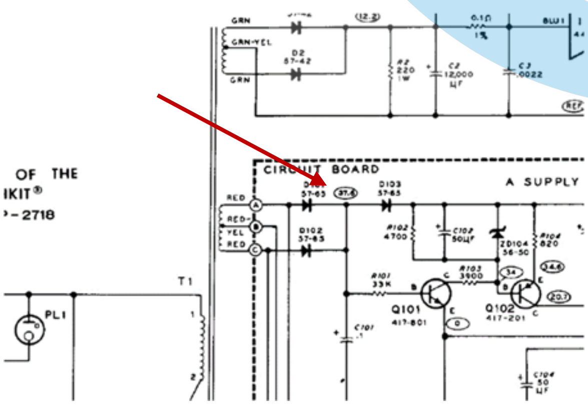

Figure 8 - Supply "A" schematic excerpt

Next up was the 20-volt “A” supply, which had no output voltage. The two 20-volt supplies are identical in design, each occupying one half of the printed circuit board (PCB) on which they are installed. As a result of this happy circumstance, it is very easy to compare the two sections as to voltage readings at various points across the PCB. Component numbering here is laid out following the rule that all “one-hundred” series components are in the “A” supply section, while the “two-hundred” components are in the “B” supply section. Thus, for example, Q101 and Q201 are the same part number and serve the same function at the same location in each of the two supply sections.

The input to the 20-volt power supply is through a pair of 1N4002 silicon diodes configured as a full-wave rectifier directly off the secondary winding of the power transformer (Figure 8). The output of the full-wave rectifier, according to the schematic diagram, should be a nominal 37.6VDC. At the anode of D103, which is the same point as the cathodes of D101 and D102, the point just referenced as the output of the full-wave rectifier, the actual voltage measured there was 0.030VDC, essentially no voltage. Voltage was present at the anodes of D101 and D102, and the voltage drop across each of those diodes was just over 36 volts. It was obvious that these diodes were both open, and therefore in need of replacement.

Due to the age of this unit, the number of electrolytic capacitors, the level of heat developed by the large power transformer, and the already verified failure of the 12,000µF filter capacitor C2, I decided to replace all of the electrolytic capacitors on the PCB. This equated to a total of twelve capacitors, six in each 20-volt section of the power supply.

I replaced all of those capacitors, installed the replacements for diodes D101 and D102, and then I checked the operation of the unit. The 20-volt “A” supply was restored to proper operation, but the “B” section was still not right. As mentioned earlier, this section exhibited an output that was too high and was not able to be adjusted to its proper level. Some more diagnosis was called for.

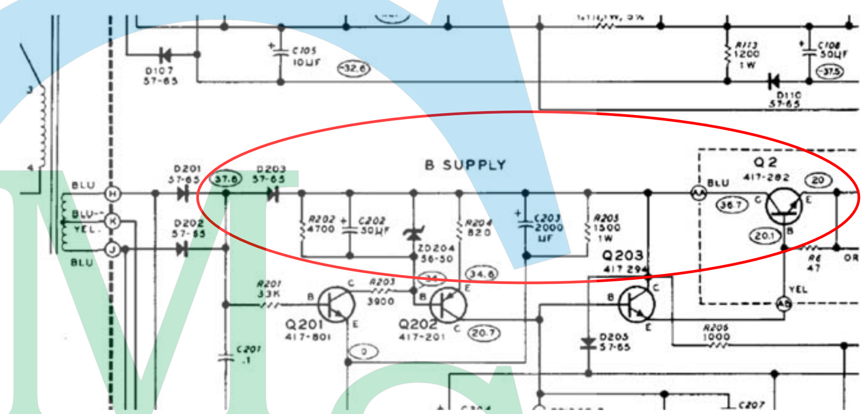

Figure 9 - Supply section "B" schematic excerpt

Mounted to the rear panel of the enclosure are three semiconductor devices. One of them is the LM309K voltage regulator IC already discussed. The other two are the pass transistors for the voltage regulator circuits of the 20-volt supplies. These transistors are of the type MJ2841 and are identified as Q1 (supply section “A”) and Q2 (supply section “B”). The MJ2841 transistor is a high-power NPN silicon transistor rated at $80V_{CEO}$, $80V_{CB}$, $4V_{EB}$, a collector current (I_C) of 10A and a base current (I_B) of 4A. The rated power dissipation is 150 watts and the device is in a TO-3 steel case. All told, this is a very sturdy and capable transistor, bordering on overkill for the job it is being asked to do in this power supply. The schematic (Figure 9) calls for an in-circuit operational base voltage of 20.1VDC, an emitter voltage of 20.0VDC, and a collector voltage of 36.7VDC. The emitter is directly connected to the J7 positive output jack for the 20-volt “B” supply and is therefore the supply output voltage. The collector voltage is one diode-drop, in this case 0.9V, less than the input voltage of 37.6V as mentioned in the section “A” discussion above. This is evident, as the only component in series between the D201 and D202 cathodes and the Q2 collector is a single 1N4002 silicon diode, D203.

The actual voltage measured at the emitter of Q2 and at the positive output terminal of the power supply “B” section was 36.9VDC, the same voltage as that found on the collector of Q2. From that information, it was evident that transistor Q2 was shorted, and thus merited replacement.

The type MJ2841 transistor is very difficult to find now, as it is an obsolete part. I found a couple of surplus houses that claimed to have inventory, and I even found a couple of ebay vendors offering the original part, but at extremely exorbitant pricing. The best price that I found was just over twenty dollars plus shipping, but I also found pricing as high as sixty dollars plus shipping. When it comes to replacement of some older semiconductor devices, a usually-viable alternative is NTE Electronics of Bloomfield, New Jersey. I have found suitable replacements in their product line-up before, and this time was no different. A look at my NTE *QUICKCross* software turned up the NTE-130 as a suitable replacement for the MJ2841. Amazon had it in stock for next-day delivery at just over five dollars. Sold!

When the transistor came in, I installed it and tested the operation of the IP-2718. It now worked properly on all three of its outputs. I gave the unit a quick cosmetic clean-up, inside and out, and buttoned it up for shipment back to its owner. Start to finish, I had the unit here for three days, shipping it out again on the third day after I received it. The quick turn-around time on this one was aided by the fact that I had all of the capacitors in stock, as well as the diodes. The only part that I needed to source and have shipped in was the pass transistor that we just discussed.

The group of electrolytic capacitors that I changed out on the main PCB included four (4) 10µF/50V axials, four (4) 50µF/50V axials, two (2) 50µF /15V radials (which I replaced with 47µF/63V radials), and two (2) 2,200µF/40V axials, which I replaced with 2,200µF/50V axial devices.

The moral of this story is that no matter how difficult a job may seem at the onset, break it down to its constituent parts and you may find that one difficult large job has become two or three easy smaller jobs. That is exactly what happened here.

See you next month!