The PRC320 PSU *Colin Guy G4DDI*

Isn't it always the way – your radio works perfectly for months on end in the shack, then the one time you take it out into the field with no backup, it lets you down – usually in front of a group of people you are trying to impress. So it was with my PRC320 HF portable when a group of local amateurs decided to have a mini-field day and I was tasked with providing 5MHz coverage.

The battery had been fully charged the previous day, the rucksack checked that it contained everything needed, including speaker, spare headset and dipole aerial and everything was loaded into the car for the "big day".
On arrival the aerial was rigged, everything set up and connected, and the rig keyed – full power and good swr. Then I realised that, listening to an ssb signal, there was a just perceptible frequency shift which related to the audio level, increasing the af gain worsened the effect. Observation revealed that the degree of shift was also related to the strength of the signal. When the set was keyed then returned to receive, it's frequency swung approximately 200 c/s above then below before settling onto the correct frequency. Subsequent reports revealed that the same effect occurred on transmit. Nevertheless some contacts were made on 60m. My first thought was that the 24 volt battery was playing up, but the battery level indicator was steady on both transmit and receive, and those of you who know the PRC320 will be aware that normally it functions to specification (apart from reduced output power) down to at least 18 volts. Operating the set from two series connected car batteries produced the same effect so the battery was ruled out as the cause. I then found that the synthesiser wouldn't lock on 40m, or indeed the upper part of any of the bands. Here then was a clue but first we need to take a look at the inner workings of the PRC320.

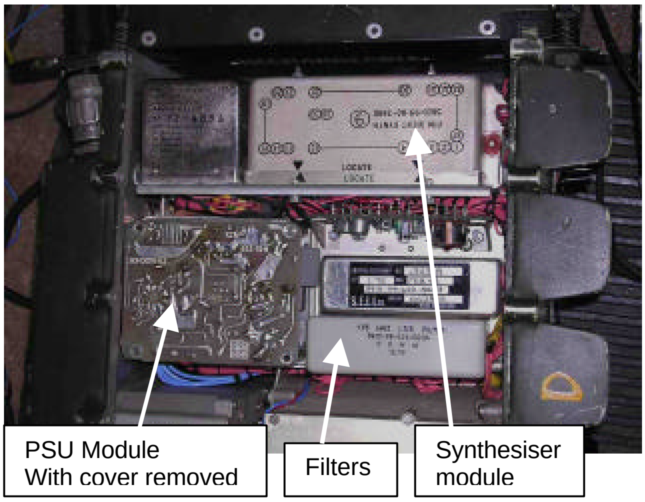

Fig. 1. Top view of the PRC320 chassis showing power supply module location in relation to other major components.

The PRC320 is a solid state ssb/cw/am transceiver with a synthesiser controlled frequency coverage of 1.950 – 29.999 Mc/s in six bands which I believe was designed in the early 70's. Most of the signal processing is carried out using the Plessey '600' series IC's which are well known to many amateurs from published homebrew designs, and were also used in some black boxes of the period. Like most solid state radios it requires a plethora of different supply voltages in different parts of the equipment. The transceiver as a whole is supplied from 24 volts, either a clip-on battery pack, a variety of external sources including vehicle supplies or even a hand generator. It is thus required that it is not too fussy about the exact supply voltage. The '600' series IC's require 6 volts, other parts require 12 volts and the digital control circuitry (lots of "surface mounted" IC's) requires 3 volts. (Plessey's designers must have been 'free thinkers', not feeling that they had to be constrained to the then standard 5 volts for digital chips!). The power amplifier stages and relay control system are powered directly from the 24 volt line, and a supply as high as 110 volts is required for the varicap tuning. (Compare with the 33 volts used for this purpose in all TV sets).
Unlike with some other equipment the designer seems to have taken efficiency and battery life into consideration, and all the voltages are produced within a screened switched-mode power supply module which is just 2¾ x 3¼ x 1", in which there are no semiconductors attached to heatsinks, and nothing gets even perceptibly warm during operation. No dropper resistors here - the efficiency must be very high.

The strange fault
Returning now to the symptoms exhibited by my set during that field day, those of you who are familiar with varicap (electronic) tuning will know that the tuning is carried out by a special diode, whose capacitance may be varied by changing the dc voltage applied to the diode in such a way that the diode is reverse biased. This replaces the function carried out by the mechanical tuning capacitor in older equipment. The diode functions in such a way that as the applied voltage is increased, its capacitance reduces, therefore an increase in voltage corresponds with an increase in frequency if the diode is used as the capacitative part of a tuned circuit. Here, then, lies the clue to the cause of the fault. Observing that the synthesiser wouldn't lock at the higher frequency end of any band I figured that the varicap supply wasn't able to reach a sufficiently high voltage to tune the high end of the band. (A similar fault commonly occurs in television sets whereby they will tune the low numbered channels, but not the higher ones.) An investigation of the power supply module revealed that this was indeed the case.

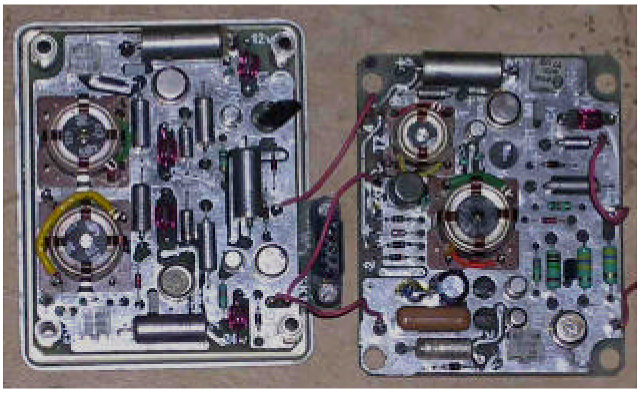

Fig. 2. The two pcb's separated.

The Power Supply
To get to the power supply, it is first necessary to extract the set from its case. Begin by removing the dessicator then undo the 14 Allen screws from around the rear periphery of the set, and carefully ease out the rear casting, taking care not to damage the sealing gasket (these seem to be rarer than the proverbial rocking horse product!). Now unscrew the 14 Allen screws from the front and similarly remove the main assembly from the case. (By now you should be fed up with the sight of that Allen key unless you have an electric one!) It will be seen that the two halves can be reconnected together by carefully relocating the Cannon plugs/sockets on each assembly.
The battery can be clipped back on and the set operated out of its case if necessary. The power supply in its screened case can be clearly seen on the top of the main unit. With the

battery disconnected the two screws in the top of the unit can be removed and the cover lifted off. (Fig.1). It will be seen that the supply unit consists of two pcb's mounted one above the other with the component sides facing together. The top pcb contains the 6 volt and 110 volt regulators, and test points are clearly marked for these voltages.

At this stage I reapplied the power and checked the voltages. The 6 volt rail was spot on, but sure enough, the 110 volt one read only 45 volts and was wavering by a volt or two. There was also a distinct smell of something warm so I switched off and investigated further.

By removing the two screws in the top pcb, it is possible to remove the complete module from the set, to which it remains connected by a short lead and multiway plug. The top pcb can be separated from the bottom one, which contains the 12 volt and 3 volt regulators, by carefully removing two circlips from the supporting pillars. It will be necessary also to unsolder two of the wires linking the pcb's. These can be extended if it is necessary to operate the set with the psu dismantled. The two pcb's are shown in Fig. 2. Further tests showed that the 12 and 3 volt rails were as they should be.

I have not been able to obtain a complete circuit of the unit, but Fig.3 shows what I have been able to trace out of the area where the fault is.

TR3 is driven by a squarewave derived from the control IC (ML1 – CN587T), and the transformer T2 in its collector steps up the 12 volts to something like 130 volts after rectification by the bridge rectifier. The remaining components then serve to stabilise this to 110 volts, adjustable by R11 on the side of the pcb. It didn't take long to discover that the "hot" smell was coming from TR3, which is nothing more exotic than a BC107 – the sample in my set had turned a delicate shade of blue in its struggle to continue to provide a supply to the varicaps! Suspecting (dreading?) a possible short or leak within the inner depths of the set, I disconnected the regulator output lead from pin 1 of the pcb – result still 45 volts and a hot running BC107 – phew! The voltage on TP2 (130 volts) was about the same.

Static (ie with power disconnected) tests revealed that TR6 (type unidentified) was very sick, sort of leaky in all directions, and TR5 and TR7 were both short circuit.

The CN427 IC ML2 as far as I have been able to find out is a transistor array and in this circuit is used as a precision zener diode. There was no reading either way between pin 6 and 7 with an ohm meter. It was starting to look like the chain of

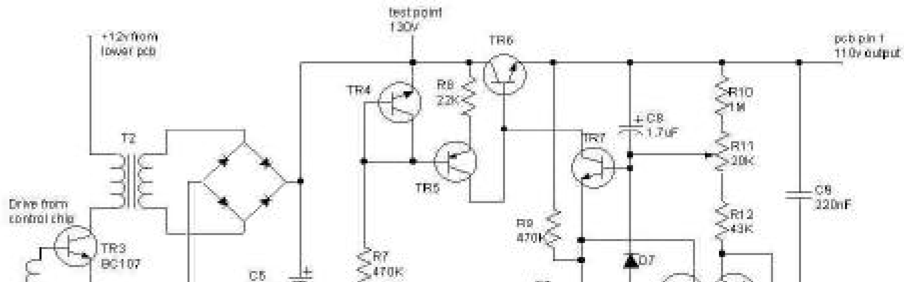

Fig.3. Circuit of the 110V regulator as traced out by the author.

destruction familiar to those who have had to repair early transistor audio amplifiers, though I couldn't find any other suspect components!

Removing the three duff transistors and applying power again, there was over 150 volts at the rectifier output and the BC107 was happily cool now. What to replace those unidentified transistors with? I figured that TR6 and TR7 (both NPN) would have to be high voltage types so I resorted to my scrap TV panel box for a couple of video output transistors – these normally work at over 250 volts. TR6 (PNP) was replaced with a BC158 and power again applied. I had around 120 volts at the output of the regulator and the synth now locked on 40m, but there was a nasty random wavering of the frequency of the set which made ssb all but unintelligible. The 110v adjustment pot had no effect either. The regulator output could be seen to be wavering up and down by 5 volts or so in time with the frequency variations. And there was still that 'hot' smell.

I figured that the emitter of TR7 would need to be set at some fixed voltage by the zener action of the transistor in ML2 but at what voltage? There was around 12 volts and wavering on the emitter, to be expected as this point is fed from the output via R8. I connected a 100k pot from the emitter to earth and by monitoring the voltage across it as I adjusted it, and the output voltage at the same time, I found that output voltage began to drop as the emitter voltage was pulled down to around 6 volts, but there was still that wavering and the 'hot' smell, so some current was going somewhere. Clutching at straws, I removed C8 and C9. Without these components I found the output voltage to be quite stable and with the emitter voltage set to be 5.7 volts the output was 110v and could be adjusted a little with the preset on the pcb. I removed my pot and connected a 5.1 volt zener and a 1N4148 diode in series from TR7 emitter to earth to stabilise the emitter voltage at 5.7 volts. Result exactly 110 volts, adjustable and stable, but with noise on it, expected without the decoupling capacitors in circuit. I reconnected the regulator output to the set, and the synth locked up – very quickly indeed, with barely any of the "whistling up" that is normal with these sets, hmmmm…

Turning back to the two removed capacitors, C9 (0.22µF polyester) proved to be faultless and was refitted, but C8, a 1.7µF 150v tantalum type had a measurable resistance of about 10MΩ. I suspect that at some time its resistance had been lower, and had led to the destruction of the other components. I hung in the nearest I had, a 2.2µF 400v electrolytic and switched on – the 110 volts came up very slowly over several seconds, with a correspondingly long lockup time for the synth. Without the capacitor the supply came up almost instantly, so why was it there, and why that strange value?

Two possibilities I can think of: firstly to provide a 'soft start' for the regulator and varicaps, and more likely so that the synthesiser oscillator is 'swept' from the low end to the high end of its frequency range on switch-on slowly enough to ensure that it finds its locking point on the way without overshooting it. The designer must have arrived at the odd value as giving the time constant that is the best compromise to achieve a reliable lockup in a reasonable time.

In the end I fitted a 1.5µF polyester TV type component, which took a bit of thinking about as it is much bigger than the original, but in the end I managed to squeeze it back into that screening can. To date the CN427 IC remains open circuit and shunted by the zener diode arrangement until I can find a replacement. I also replaced TR3 just in case as it certainly looked 'cooked', though it still measured OK. Performance seems as good as before, though I suspect that the temperature compensation will not be as effective as the designer intended, but then I'm not intending to operate in the Arctic or the Sahara!

Conclusion

It actually took me longer to type this story out than it did to diagnose and repair the fault – the aim of doing so is to demonstrate the fact that, although these are not easy sets to work on, they can be repaired by the ordinary amateur, the technology in them is not rocket science, and as they have been around for getting on for 30 years, I think that they'll outlive the modern 'Lynchyboxes' that the owners have no idea of how sort them if something goes wrong.