Technical Topics

Take a Look Inside the HP10811 dual oven

Intimidated at the prospect of servicing your Z3801A oven oscillator? In this article, Steve Smith, G8LMX (Nottingham, UK) shares his experience in exploring the inner details of the HP 10811 dual oven used in the Z3801A GPS receiver.

After many years of using a Sulzer precision oscillator as my primary frequency reference, I decided it was time to update. At this time the obvious choice based on accuracy versus cost was the Z3801A. These appeared in abundance on Ebay, and on the fourth attempt I secured one. After waiting two weeks it finally arrived. I built it into a 19" rack chassis, designed and built a regulated power supply with four sealed lead acid batteries, put my antenna on the roof, and switched it on.

After a short while the GPS Lock LED lit. "Is that it?" I thought. After checking the 10 MHz output several times, I resigned myself to the fact I would have no more fun. There was no point in using the VLF receiver tuned to the local frequency reference station as I did with the Sulzer every month, as any long-term error would most likely be their fault anyway.

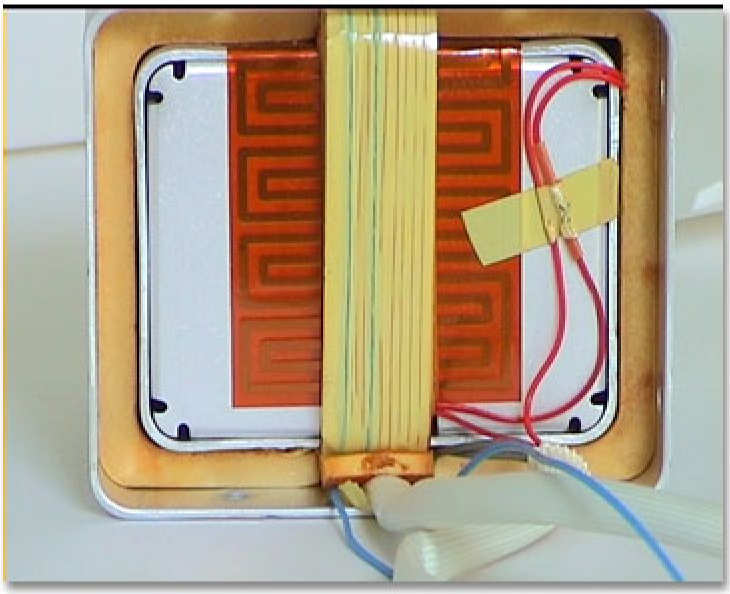
Graham Baxter, the program author of GPSCon and also a friend of mine had purchased a Z3801A some weeks before and had started writing a program to log the long-term performance of his receiver. GPSCon at this time was in the early stages of development, but already showing promise.

From the start, GPSCon showed me that all was not well with my Z8301A. GPS lock light or not, the EFC count changed erratically, sometimes more than 1000 counts per day! I felt quite disappointed. Then I realized this could be far more interesting than using a paper chart recorder on the Sulzer for two days every month. With GPSCon I could see changes and trends in real time, while the performance when locked to GPS far outstripped my Sulzer, it should be better. So I set to work. After many days of adjusting my antenna, power supply, receiver positioning and even maintaining the room at a constant temperature, nothing I did had any affect. It was time to find out the cause by the only way I knew how.... swap pieces with a known good one. Now where could I find a good receiver, and someone willing to take his apart?

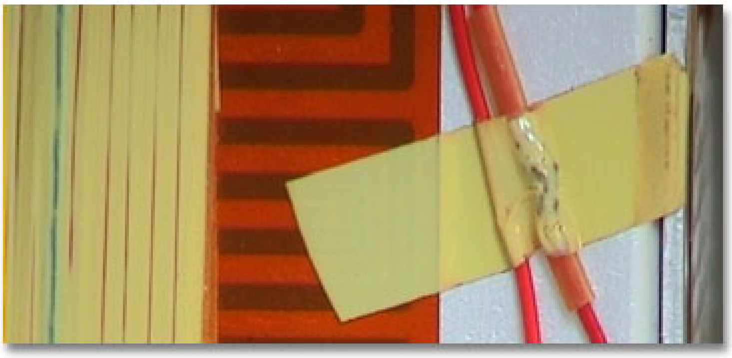
Graham did the honorable thing and after a day of juggling we proved conclusively the OCXO was the culprit. Graham's oscillator had been very well behaved since day one, and in my receiver after a few hours of plotting with GPSCon it did exceptionally well. There was only one thing left to do: disassemble my OCXO. Gulp!!

The Outer Oven.

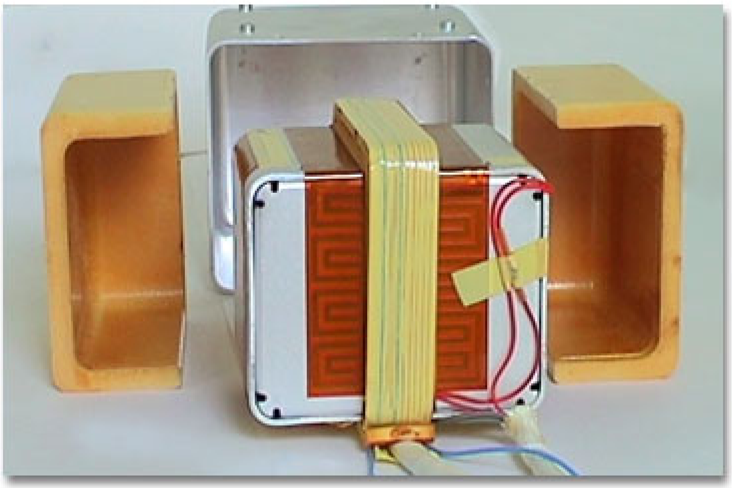
The removal of the OCXO is straightforward. Disconnect all leads from the rear of the receiver and remove the top cover. Carefully pull the 10 MHz and EFC SMB connectors off the motherboard followed by the outer and inner oven connectors. Remove the four Torx screws holding the oven to the chassis bottom, try not to bump it around as this could induce stresses in the crystal mount. At this point I created a very clear, clean well-lit area on the bench, in effect a mini clean room. Remove the screws around the periphery of the base and carefully remove the base cover.



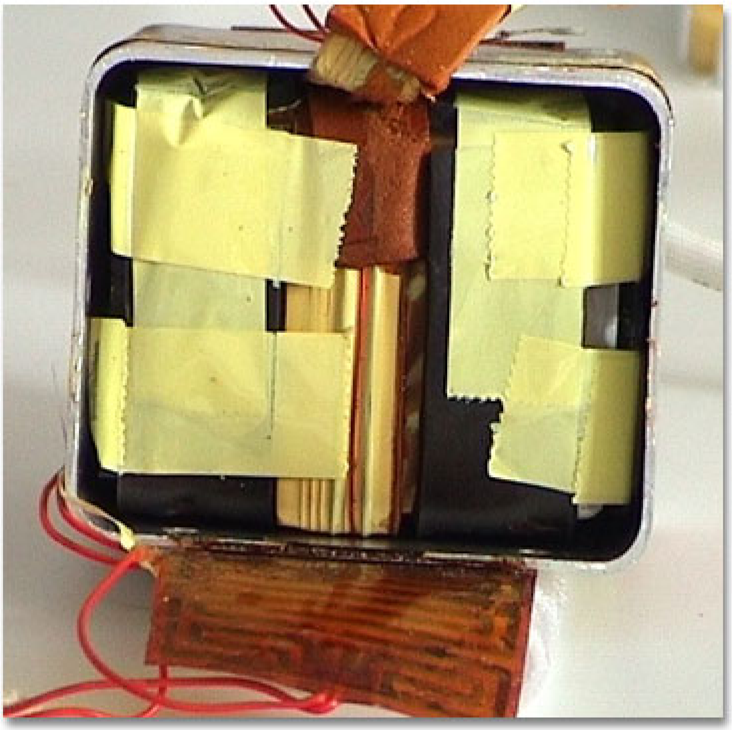
Inside is the outer oven you can see the orange oven heater film, there are two of these heaters in series with a total resistance of around 18 ohms. The wires from the outside world to the inner oven are wound round the outer oven on foam rubber tape, this is most likely done to attenuate thermal shocks traveling to the inner oven. The tape joint in the red wire is just that!



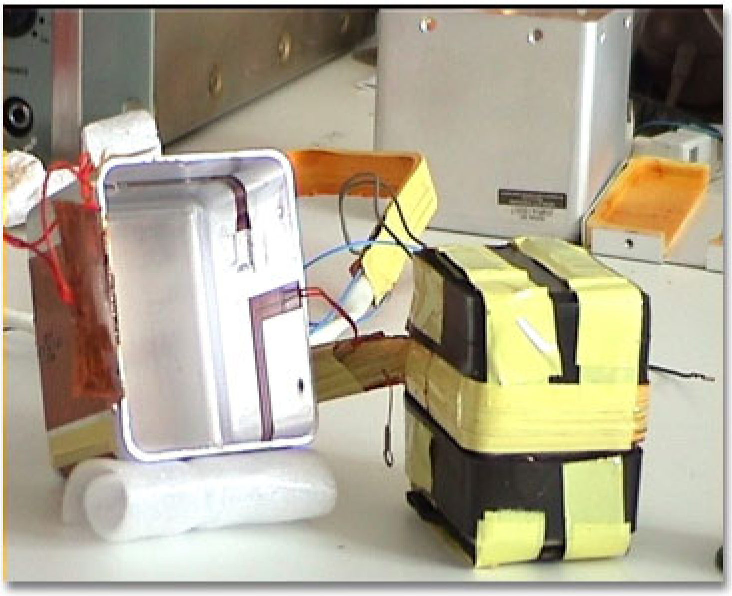
Now remove the outer oven from the casing. I did this by just pulling gently on the lead-out wires and it all slid out easily. Keep note of insulation position and oven orientation.



Now comes a tricky part. After removing several strips of yellow polyester tape, unwind the lead-out wires from the oven. The foam is stuck in places so care is required. Try not to contaminate the ovens, the inner oven in particular. Oils from the skin or bench will evaporate at oven temperatures adding extra thermal anomalies; you could make it worse! Very carefully lift the heater tape from the bottom of the outer oven. If you do this slowly the adhesive remains mostly on the tape. The outer oven has screws around the bottom just like the oven outer casing. Remove them. As you get closer to the inner oven things get more and more stuck together so slow down! The tapes and glues in my oven still came apart, it just took longer for them to separate as I pulled. Once the bottom of the outer oven has been removed the inner oven insulation can be seen.

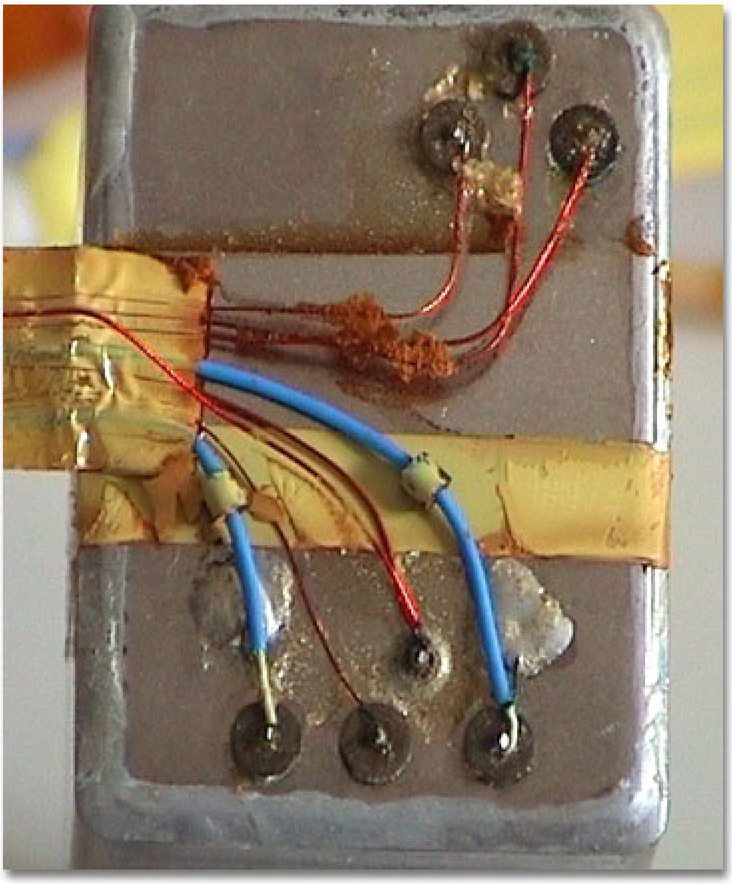


In my oven this was a soft, sticky, black foam rubber material held in place by yet more yellow polyester tape. Pulling out this sticky lump was a bit of a worry, but with time and persistence it eventually came out.



In the photo you can see the outer oven thermistor within the oven can. There were four thin strips of black foam rubber taped to the insulation. I assume these were used as packing. After removal of the insulation the lead-out wires need unwinding, again being careful not to tear the foam backing. You should now be down to the basic HP 10811 oscillator and inner oven.

Make a note of the connections and remove the wires and the small card discs from the pins.



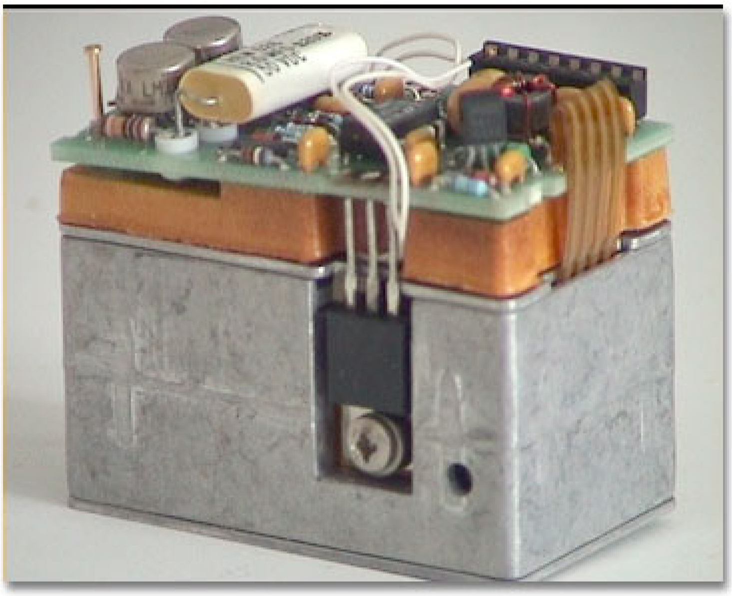
At this point I cleaned the oscillator unit with isopropyl alcohol to remove the glue residue as the next part involved getting it a bit hot!

The Inner Oven.

With the inner oven nice and clean its best to sit back and admire it while you contemplate the next part. Before attacking the oven with a hot stick (soldering iron), remove the screw from the frequency adjusting hole. The oven can is soldered together with the base lip about 4-mm into the can itself. The method of removing the base will vary depending on the equipment available to you. As it turned out it came apart nicely. I used a micro-flame blow-lamp (blowtorch) (gasp I hear) and a desoldering station with a suction pump.

Although the desoldering station iron is 100 watts, it alone could not get the solder flowing sufficiently. Using the micro-flame blowtorch I heated the solder until quite fluid and using the desoldering iron and pump I sucked the solder away trying all the time not to overheat the oven. I decided that if it got too hot to hold at the top of the oven it was probably time to rest and let it cool down some. After three such rests I had sufficient solder removed to attempt to lift the lid. I used a modeling knife blade to crack the remaining solder just by gently pushing the blade between the oven can and the lid lip. Then with a small sharp screwdriver, I slowly pried the lid, bit by bit, until it just popped out. **Don't pull**! Under the lid is a thin, easily damaged, flexible ribbon.

This ribbon terminates with pins that push into a socket on one of the inner oven circuit boards, a potential cause of problems I suspect. This board is the oven controller with the thermistor bridge, error amp, heater control, current limit and 10 volt regulator, although in my oven this turned out to be a 5 volt regulator. On the sides of the oven are the two heater transistors. The gold pin in the corner of the board is a ground post.

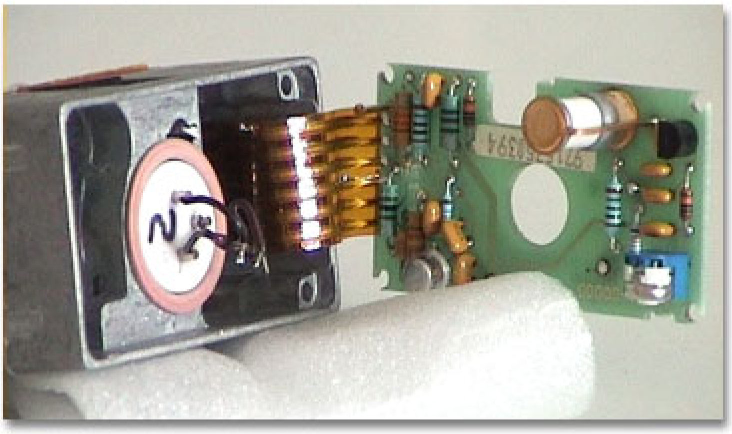


Four screws hold the assembly together. After removal of these, the top cover can be removed and a base cover can also be slid out gently, noting orientation of parts at all times. The two white wires go to the thermistor mounted in the crystal housing; these wrap around the middle board.

With the covers removed, the base of the crystal and the glass piston trimmer can be seen on the top side of the assembly.

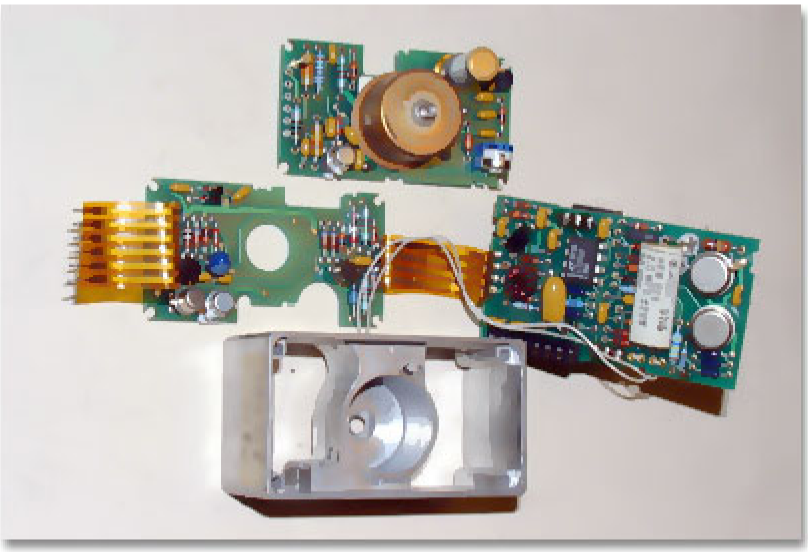
I was quite surprised to see marks on the adjusting slot of the trimmer as the oven assembly appeared not to have been apart before.

The crystal has three wires spot-welded to its pins. The wires are stranded and did not look well attached so again care is required. Unsoldering the wires from the PCB allows the oscillator board to hinge on a flexible connection allowing measurement, or replacement of parts.



This board contains the oscillator, varicap and the amplitude adjusting pot. The third board contains the ALC circuit, a voltage reference and an emitter follower. After basic checks no obvious fault could be found, but the exercise had paved the way for later investigation. I removed the crystal, which is seen here next to a UK penny.

The crystal is held in the die-cast assembly with a nut and locking washer. On my oven this was not very tight!



10811 Inner Oscillator Major Parts

Summary.

At this point I have to say that my journey into the depths of the 10811A oven was more out of curiosity than any belief that I could improve its performance. It has, however, given me a tiny bit more understanding of the black art of oven design. The oven was reassembled and put back into service with no apparent deterioration or improvement in performance. In reality it seems to be improving on its own. If it continues to improve I estimate it will be a good one in about 5 years!

I only tack soldered the inner oven because on my next trip inside I intend to bring out some wires to monitor interesting signals. For example, if I plot the 6.4 volt regulated varicap reference I may find a correlation with my wandering EFC plot. The 5-volt regulator for the thermistor bridge is another potential candidate. I'm currently building a PIC based A to D interface to a computer serial port. This will allow plotting and comparison with GPSCon data plots.

Since Bill, K8CU, has started the Web-Plot page, a selection of receivers has been available for comparison. In one respect I should just leave my receiver alone and be content; it is not the worst!

I hope my contribution will spark interest among receiver owners to solve the problem of varying performance levels in the receivers.

Steve later determined the cause of his oscillator problem. He adjusted the crystal oven temperature to match the crystal temperature turning point. Full details are available here.