HP 8640B Restoration Project

1. Trouble shooting the generator.
   I purchased a HP 8640B on an eBay auction as scrap, hoping that it would be in reasonable condition. My heart sank when I opened the package --- it was in very sad shape. Evidently, a long productive life in service; very dirty, scratched, and ding'ed up. Also evidence of life at sea, judging by the amount of corrosion and oxidation.

   HP built these beauties to last that made me feel that it deserves a bit of TLC. I already have two other units, albeit, later serial numbers, and this would make a welcome addition to the lab. So, effort was spent cleaning, polishing, and doing oxidation damage control.

   Time came to look what was functionally amiss. Of course, it was dead. First issue was the -5.2V DC supply LED did not light up. Other supplies looked OK. Quick check showed the -5.2V fuse was blown, which was replaced but promptly blew. So, checked the current draw on the -5.2V --- it was over 2A, not quite a short circuit.

   In order to continue testing, a stiffer external -5.2V supply was patched in. It held at 2A, no smoke. No RF output either and the counter showed zeroes. First thought was that the cavity oscillator was at fault. Following the suggestions of an old QEX article on restoring the 8640 cavity oscillator, cleaned and lubricated the mechanism. An RF millivoltmeter found the cavity oscillator healthy, so on with the search as to why there was no RF output.

   The cavity feeds into an RF divider module. Opening the RF divider module, noticed that it looked somewhat different than my other units. Must be that these older serial numbers used slightly-different parts. It did not take long to discover that some of those golden proprietory HP chips was dead too. Those are special ECL parts and long obsolete. Since those ECL chips are powered from the -5.2V supply, there was a hint was that something happend to the -5.2V regulator module that took out some of the ECL parts when it failed. Fortunately for me, I found a replacement divider board on eBay that solved that one. Once installed, the replacement board worked fine --- now there was RF output, at least at the pre-amplifier stage, though no output at aux output, sure sign the preamp hybrid was bad too.

   Turned out the HP hybrid preamp was blown. This apparently, is not uncommon for HP 8640B's. Having gone through fixing those, went ahead and did the MAV-11 fix. It was nice to see RF output, even the meter came to life showing good output. A quick check indicated the AGC was working and the unit was even in reasonable state of calibration. Next item that needed fixing was the counter.

2. Fixing the HP 8640B counter.
   Evidently, someone had already looked into why the counter was not working --- there were a number of screws missing; holding covers down, also holding circuit boards down.

   The counter has three boards: timebase, counter logic, and prescaler. The timebase and counter logic contains 74LS logic which is good news. The prescaler, however contained three of those golden HP ECL parts, which was not good news as they also depended on the failed -5.2V supply. Further bad news was that the schematic I downloaded off the net did not match the prescaler in this unit. Judging from its serial number (1828A09007), apparently my unit was an early unit -- one had to navigate without the schematic.

A quick check using the external counter input showed that the counter was at least functional in the EXT, 0-10 MHz mode. In that setting, most of the prescaler functionality is bypassed ... at least a bit of good news.

Upon visualizing and guessing a probable signal path through the prescaler, I came to the conclusion that it was likely that not all golden HP ECL parts in the prescaler was dead. At least, the analog amplifiers and a front-end divide-by-two chip was working. However, the signal stopped dead at a divide-by-16 part (HP 1820-1003). That part is mounted on two standoffs with mica washers with its pins plugged into sockets on the circuit board. How did we know that was a divide by 16? I first puzzled out the signal in and out pins, then jumpered in to out, bypassing the chip's functionality. With the counter in EXT 10-550 mode, it showed 16 times the actual frequency, so the 1820-1003 must be a divide-by-16 ECL part. Neat, this means only one chip needs to be replaced as the rest seems OK.

Replacing the whole counter is and expensive proposition, costing way more than the generator is worth, so that was unfeasible. Either the unit was to be used as is, without the counter, or some plan needed to be devised to replace the blown 1820-1003. I decided to leave to project alone for a while to explore options.

Then I came across the MC12093, a 1.1GHz prescaler chip. The chip can be programmed to divide by 2, 4, or 8 and it was available from Digikey, so that looked like a winner. All that needs to be done was to figure a way to interface it with ECL. I made up a small piece of double-sided PCB and glued two MC12093's dead-bug style to the PCB. Just a few connections are needed to make the divide by 16. Thought it might be touchy as the maximim frequency was around 500 MHz and dead-bug style with point-to-point wiring might not be such a good idea. Anyhow, we pressed on. Keeping ECL logic convention in mind, the MC12093s were wired with VCC grounded, the ground pins wired to -5.2V. Any other points that normally would be grounded, also was taken to -5.2V.

The replacement module was soldered close in proximity to where the 1003 chip used to be, input and output was connected and the final moment arrived. Dissapointment --- the counter did not work either in INT or EXT 10-550, settings ... more mystery. Investigative scoping of signal levels showed the replacement part was actually working correctly, however, the interface with the following ECL part was not quite right. Levels were switching but margins were different. Incidentally, the part we were trying to interface with happens to be a generic Motorola ECL part. Comparing voltage levels at other parts around the prescaler board showed an apparent difference in ECL thresholds between the HP and Motorola parts. The HP 8640B designers overcame this difference by cleverly shifting the HP ECL level to the Motorola ECL level. Simply send the MC12093 output through two series silicon diodes (1N4148), the first diode's cathode tied to the MC12093 output pin. Finally pull the second diode's anode to ground (ground this time, not -5.2V) and apply that to the Motorola ECL chip input. This time, the counter was showing proper frequency on EXT 10-550 mode, but unfortunately, erratic on INT. Apparently the high frequency from the cavity oscillator did not quite make it into the newly-installed prescaler.

The final step to complete fixing the counter, involves the matching of the MC12093 input at high frequencies; Evidently, at UHF frequencies, dead-bug style construction and point-to-point wiring causes some mismatch at the input of the prescaler chip. It was OK when in INT 10-550 mode because the frequencies are lower, whereas INT mode has to count the output of the cavity oscillator that is in the 400-600 MHz range. On a PCB design, one probably can engineer proper strip-line interconnections for a proper match and limit stray effects, but designing a special PCB at this point was not feasible. Fortunately, there was an easy solution. After experimenting with various pullup and pulldown resistors and seeing no difference, I tried a small series inductor in the new prescaler chip input circuit. That seemed to have the desired effect --- presumably, the inductance gives the needed impedance match and the new prescaler chip sees a cleaner signal. The inductor is made of a few turns #26 wire, about the diameter of a 4-40 screw. Happen to be in the junk box.

3. Fixing the -5.2V module.
   The final bit left to do was to fix the broken -5.2V module. After fixing the bad ECL chips, the current demand also dropped, what was what we expected. After some effort, the regulator module failure was traced to a blown uA723 regulator. Replacing the IC brought the -5.2 module back to life. But the story does not quite end there.

   Whilst peering into the guts of the HP 8640B, which seems like a long time by now, I was puzzled by the odd discoloration around the connections of the main power transformer. Looked like something got very hot there. I was hoping that the power transformer was'nt bad too. Looking at the area in question under magification, it appeared that some of the PCB connections actually have corroded. That extra resistance caused the PCB connections to overheat --- actually melting solder. That prompted me to wick out all the old solder and remove the power transformer for closer inspection. Surprizingly for HP quality workmanship, this might have been a manufacturing problem. It appeared that the heavy transformer wire connections were not properly cleaned abd tinned prior to soldering resulting in poor connections to the motherboard. Well, that was easy to fix. Also made an effort to beef up the solder tracks to improve current-handling capacity and nice clean solder joints.

   In postmortem: what really happened with this generator? Just my guess, but I think it started with the solder connections on the power transformer. With age, those heavy-current interconnects probably deteriorated to a point where they became intermittend. Who knows what bad things happened next, likely the uA723 on the -5.2V module failed that might have done something bad to some of those HP ECL parts. End result: -5.2V module failure, RF divider module shot, and the counter prescaler dead.

The finished signal generator, ready for use.

Hope this helps someone thinking about fixing an HP 8640B,
73, de KC7WW.

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