RF Probe Design and Build for Conar 231 Signal Tracer

I am currently in the middle of a repair to a Conar 231 Tuned Signal Tracer (Figure 1), circa 1978, that came in to my shop in an inoperative condition. That repair will be the subject of another article, most likely an *At the Repair Bench* short. The subject of *this* article is the fact that the owner of this signal tracer also needed a probe that is suitable for use with the signal tracer, as he bought the unit used and it did not come with either a manual or a probe.

Figure 1 - Conar 231 Tuned Signal Tracer

I did some research and determined that the unit requires the use of an active RF amplifying probe, so I set out to design and build one for him. While it may seem backwards, I actually started with determining what I could use as the body of the probe, as that would determine the dimensions of the printed circuit board (PCB) that I could fit inside of that body. I was at a loss for a suitable probe body for quite a bit. I considered using the clear plastic penny tubes that I have used before, except that the interior dimensions would not support a PCB any more than about a half-inch wide by about two inches long. In addition, I would have to copper-wrap the tube for shielding and ground purposes, and then cover the copper wrap for an acceptable outward appearance. What I really wanted was a metal tubular body of adequate size in both length and diameter. A metal tube would be naturally shielding and could be tied to the ground of the PCB and cable.

Figure 2 - Solder-sucker tool

After a bit of thought and looking at various options, I hit upon an ideal solution. I have several of the aluminum tubular plunger-type solder-sucker desoldering tools (Figure 2). Some of them have threaded caps on the two ends of the tube. The tube dimensions are 3.3 inches long by 0.7 inches inside diameter. The space available for a PCB ends up at about 2.5 inches by about 0.65 inches. I decided to use one of these tools as the base body for the probe. The Teflon™ tip would serve as a great support for the probe tip, which I would fabricate out of a short length of 10AWG solid wire, stripped for about a quarter of an inch at the outer end and filed to a point.

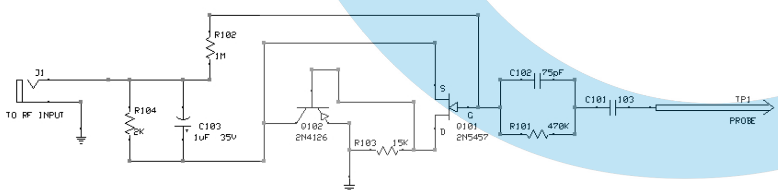

Figure 3 - RF probe design schematic diagram

With the tube dimensions in mind, I began the electronic design work, starting by drafting a suitable circuit, as shown in the schematic in Figure 3. I designed the probe circuit to use commonly-available components that I had in stock, including a 2N5457 N-channel FET and a 2N4126 PNP transistor, both of which are in the ubiquitous TO-92P case. Then, I designed an appropriate PCB and had it put into production. The PCB design is shown in Figure 4.

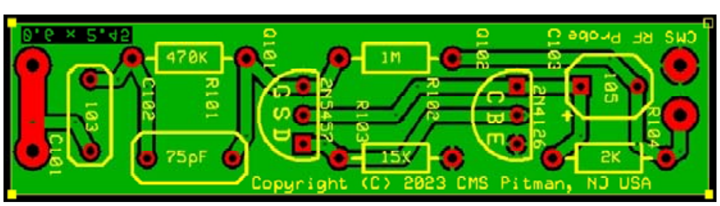

Figure 4 - RF probe PCB design drawing

A few words are called for as regards the design of the RF probe circuit. An important consideration was the desire *not* to load the circuit under test. To that end, the probe circuit was designed as a high input impedance circuit using a 2N5457 N-channel field-effect transistor in a source-follower configuration. The signal is then amplified in the probe to the requisite level for the input of the signal tracer, and is directed into the signal tracer through the input BNC connector. From there, the signal is fed into the coarse attenuator at the signal tracer input. The design of the probe circuit, in avoiding loading the circuit under test, provides a signal to the signal tracer that is as faithful as possible to the original signal in the device under test.

It may seem counter-productive to first amplify the signal and then to attenuate it, but there is a logic to that methodology. The idea is to have a signal of a known level progress through the signal tracer. In order to do that, the actual incoming signal must be of a greater amplitude than the signal to be processed within the tracer. By amplifying the signal in the probe, we provide that higher signal amplitude, at a level high enough that the attenuator circuits can then pick off the desired signal level for processing.

Figure 5 - Tool parts for probe fabrication

While I was waiting for the PCB's to arrive from the manufacturer, I began the modifications to the solder-sucker tool to turn it into a probe body. I began by disassembling it into its three main parts and cleaning out all of the residual solder particles that were inside the unit. I then cut the pushrod for the plunger and removed the plunger and its detent from the upper cap of the tool. Next, I roughly cut off the plunger surround shell, and then followed that with a precision trimming of the cap to the desired final length. I did the cutting of the plastic cap using a rotary toothed saw blade in my Dremel® tool. The resultant parts left from which I would fabricate the probe are shown in Figure 5.

The next step was to prepare that cap for the installation of an unswitched 3.5mm mono TS phone jack which would be the mechanism by which the input cable to the signal tracer would attach to the probe. To prepare the cap, I first had to remove a portion of the support sleeve for the former plunger pushrod. I did this in the drill press, using a 3/8" twist drill and supporting the cap in my drill press vise.

Figure 6 - Jack in end cap, with plug

Drilling out the center of the support to the requisite depth was quite successful, though it did leave a thin shell of the support behind. I then went back to the Dremel® tool, this time with an end-milling burr in the chuck. This end-mill made quick work of removing the shell and leaving a flat surface against which I could install the jack. All that remained was to drill out the original plunger pushrod bore to a diameter suitable for the threaded bushing of the new phone jack, a task once again done in the drill press. The resulting end cap, with the jack in place, is shown in Figure 6, together with the connecting plug that will be used.

Now, I could obviously have run the connecting cable straight through the end cap and soldered it directly to the PCB, and it would have worked just fine that way. However, I wanted to build in some dependability. Using the solder-sucker tube as the probe shell, with its truncated plastic end cap, does not provide for very much in the way of strain relief for the connecting coaxial cable. Plugging the cable into the probe creates a swivel point at the end of the probe, reducing stress on the cable assembly, which increases its dependability. In addition, making the cable such that it can be disconnected from the probe body also makes for easier overall storage of the unit.

Figure 7 - Probe tip assembled

The connecting cable was fabricated form a four-and-a-half foot (fifty-four inch) long length of RG-58 coaxial cable. Of course, the probe end was soldered to a 3.5mm TS phone plug, while the signal tracer end was provided with a 50Ω male BNC connector to mate with the female BNC jack on the front panel of the signal tracer unit.

As already mentioned, I fabricated the probe tip from a short length of white-insulated solid 10AWG wire. I slid the wire through the Teflon™ tip from the inside, leaving about three-quarters of an inch of the wire length sticking out from the end of the Teflon™ tube tip. I then stripped a quarter-inch of insulation from the protruding wire, and then filed the revealed copper wire to a point (Figure 7). The inside end of the wire would later be shortened and stripped, and then soldered to the PCB at the correct location at the end of the board. The board is designed such that the wire can be passed through one hole, brought across the board part of the way, and then inserted into a second hole. It would then be soldered at both holes, providing plenty of strength for the probe tip. As time goes by, the wire point can be refiled to renew it as necessary.

Figure 8 - Completed probe assembly

The assembled probe, shown in Figure 8, is clean and compact. The tubular aluminum body shell is connected to the internal PCB ground via a brush wire protruding from a ground point on the board and dragging on the inside of the tube. To accompany the probe is a ground wire, simply made from a length of black 16AWG silicone test lead wire with an alligator clip on one end and a banana plug on the opposite end. It plugs into the ground banana jack on the front panel of the signal tracer. The whole thing, including the cost of the solder-sucker tool, comes in for less than twenty dollars materials cost, not bad for what it is and what it does. I am quite happy with the end result and I believe that the owner of the signal tracer will be happy as well. Oh yeah – I also sourced a digital copy of the manual and provided that to him in printed form as well. Full-service repairs!